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# Sydney Tar Ponds Clean-Up

## SHORELINE INVESTIGATION REPORT

## PHASE II

## March 1990

Environment Canada - Environnement Canada

Shoreline investigative report : phase II

ACRES INTERNATIONAL LIMITED

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# 1 Introduction

Acres International Limited (Acres) was commissioned by the Nova Scotia Department of the Environment (NSDOE) to provide project management services for the clean-up of the Tar ponds at Sydney, Nova Scotia. One concern raised regarding this clean-up was whether tar pond type materials were within, or under, the fill bordering the southeast shoreline of the upper Tar Pond and the area surrounding the Sydney Shopping Centre. A considerable portion of the former area lay on the seaward side of the old shoreline prior to 1900 (i.e. approximately the time at which tar-contaminated materials were initially disposed of into Muggah Creek via Coke Oven Brook) while the latter area was originally low-lying and required fill materials to reach its existing grade.

To address the above concern, an investigation of this area was carried out by Acres in November 1988. The results of a drilling program confirmed the presence of tar pond materials under, but not within, the overlying fill. In terms of assessing the remedial clean-up alternatives for this area, it was recommended that further drilling take place with the following objectives:

- provide a better indication of the extent and thickness of both the contaminated material and overlying fill

- obtain hydraulic information on the local groundwater flow system

- ascertain whether the contaminated material under the fill is similar in its thermal characteristics to the tar pond materials.

The follow-up investigation was carried out by Acres in October 1989. This report provides a summary of this investigation which involved the drilling of boreholes, soil sample collection and analysis, installation of monitoring wells and field tests. Section 2 outlines details of the field program and the laboratory analyses performed while Section 3 provides a description of the subsurface conditions. Section 4 follows with a discussion of the implications arising from this investigation. Section 5 concludes with a summary of this study.

# 2 Study Program

## 2.1 Field

A total of 26 boreholes were drilled along both sides of the Tar Pond shoreline and the lower reaches of Coke Oven and Wash Brooks. All boreholes were drilled from October 16 to 25, 1989. The boreholes drilled during this period were labeled BH-10 to 35. Boreholes BH-1 to 9 were previously drilled along the southeast shoreline of the South Tar Pond/Wash Brook in November of 1988. The location of these boreholes is shown on Plate 1. It should be noted that the site plan (Plate 1) was prepared from existing topographic map sheets at a scale of 1:2,400. With the exception of this map sheet and the grade elevations displayed on it, all other units reported in this document are in metric.

All drilling operations were carried out using a track-mounted CME-55 drill rig supplied and operated by Longyear Canada Inc. of Moncton, New Brunswick under the direction and supervision of Acres personnel. Boreholes were drilled to the desired depth, or to refusal, using 95-mm ID hollow stem augers. With the exception of BH-32, advancement of the boreholes using a core barrel was not carried out to avoid the potential for loss of contaminated water at the ground surface. This is discussed further in Section 3.

Auger flights were cleaned at each borehole by scraping the cuttings off the augers and returning them down the hole. The auger flights were only cleaned with water at the borehole, if necessary. At the conclusion of the drilling operation, the drill rig, muskeg carrier and all associated equipment was steam cleaned at the northwest corner of the South Tar Pond, ensuring all wash water flowed into Muggah Creek.

For all boreholes, standard penetration tests were conducted in the overburden using a 35-mm ID split-tube sampler. Samples were taken discontinuously with more frequent sampling near the interval where tar pond type materials were expected. All soil samples were examined and logged in the field, stored in either glass containers or plastic bags (depending on whether the soil indicated signs of contamination or not), and then transferred to a refrigerator. The split tube sampler was cleaned and thoroughly scrubbed with water between soil sampling operations. The location and ground surface elevation of each borehole was later surveyed in by Acres personnel. Details of the borehole logs are provided in Appendix A.

Monitoring wells were installed in three boreholes following the drilling. One well was installed in the slag materials along the northeast shoreline of the North Tar Pond (BH-33) while the other two wells were installed in fine and coarse-grained contaminated sediments along the southeast shoreline of the South Tar Pond (BH-20 and BH-21, respectively).

Each well was constructed out of 4.8 cm OD Schedule 40 PVC casing and screen with flush threaded joints. A 3.05-m length of 20-slot screen was used for each well. The well screens were packed by allowing the boreholes to collapse as the hollow stem augers were withdrawn. Clean cuttings and cement (used during the installation of a steel protective cover over each well), were used to backfill the near-surface portion of the annulus. A summary of the borehole/monitoring well details is provided in Table 1 and Figure 1.

In-situ hydraulic conductivity (k) tests were performed on these three wells from October 25 to 26, 1989. As the determination of water quality was not necessary to this study, the k tests were performed by introducing a slug of clean water into each well. Water levels were measured with an electric sounding tape equipped with a stainless steel probe. The recovery at well BH-33 was near-instantaneous while well BH-21 fully recovered within 4 hours. Well BH-20 continues to recover after a period of about 4 months.

## 2.2 Laboratory

Following completion of the field work, 21 representative soil samples were selected for PAH analysis. Seven of these samples were also analyzed for calorific content. Table 2 provides a summary of the depth interval and soil type corresponding to each of these samples and the analysis performed on them. Research and Productivity Council of Fredericton, New Brunswick performed the chemical analysis while Nova Scotia Research Foundation Corporation of Dartmouth, Nova Scotia undertook the thermal analysis.

Table 3 is a summary of the results of the PAH and calorific content analyses for the soil samples listed in Table 2. Most of the samples analyzed for PAHs were contaminated sediments or sediments which possibly could have been contaminated with tar pond-type materials. Only a few samples from the overlying fill were analyzed for PAHs to confirm the absence of tar-related contamination. The previous testing of sediments both above and below the tar pond horizon confirmed these materials were uncontaminated (see Acres, 1989). With the exception of two samples containing coal which potentially could have been contaminated, the soil samples tested for calorific content were taken from contaminated sediment. Full details of the PAH and calorific content analyses are provided in Appendix B.

# Table 1

## Monitoring Well Details

| | Well No. | | |
|---|---|---|---|
| | **BH-20** | **BH-21** | **BH-33** |
| Ground surface elevation (masl) | 7.68 | 1.22 | 3.93 |
| Water level elevation (masl) | 3.94 | 1.12 | 0.44 |
| Borehole/Well Dimensions (mbgs) (see Figure 1) | | | |
| A | 11.28 | 2.90 | 12.95 |
| B | 9.12 | 1.62 | 5.49 |
| C | 7.60 | 0.10 | 3.96 |
| D | 0.79 | 0.82 | 0.61 |

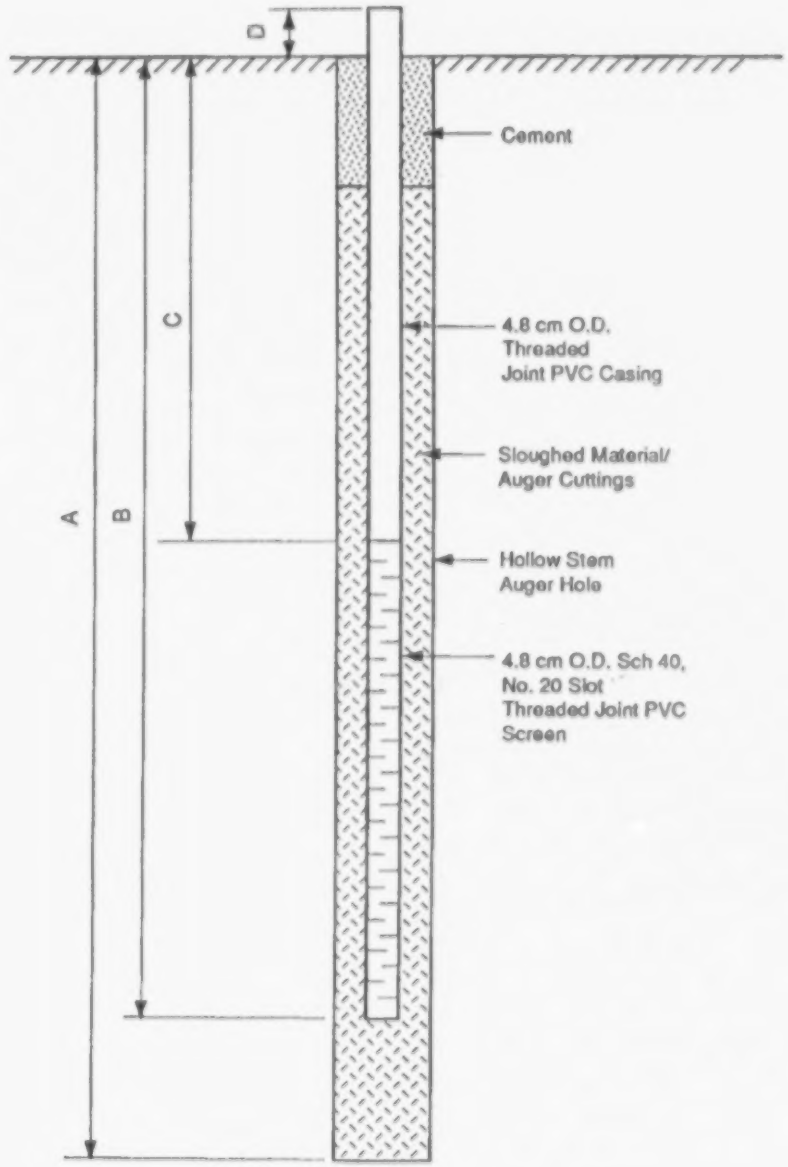
Notes:

1. Wells completed -
   October 20, 1989 for Well Nos. BH-20 and BH-21
   October 25, 1989 for Well No. BH-33

2. Water Levels measured -
   October 25, 1989 for Well Nos. BH-20 and BH-21
   October 26, 1989 for Well No. BH-33

3. masl - metres above sea level
   mbgs - metres below ground surface

4. For location of monitoring wells, see Plate 1.




Nova Scotia Department of the Environment
Sydney Tar Ponds Clean-Up
Shoreline Investigation - Phase II
Monitoring Well Details

Fig. 1

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Table 2

Description of Borehole Samples
Selected for PAH Analysis and Calorific Content

| Borehole No | Sample No | Elevation (masl) | Soil Type | PAH Analysis | Calorific Content |
|---|---|---|---|---|---|
| 10 | AQ1 | 0.73 to 0.45 | slag and ash | + | |
| | AQ2 | 0.06 to -0.52 | sand with coke/coal | + | + |
| 12 | AQ1 | 0.80 to 0.63 | sand with coke/coal | + | |
| 16 | AQ3B | 0.30 to 0.06 | sand with coke/coal | + | |
| 18 | AQ4 | 0.74 to 0.61 | sand with coke/coal | + | |
| 20 | AQ4 | -0.70 to -1.15 | silt with coke/coal | + | + |
| 21 | AQ2 | -0.30 to -0.45 | gravel with coke/coal | + | + |
| 22 | AS1 | 6.31 to 6.03 | silt with coal | + | |
| | AQ5 | 0.93 to 0.80 | sand with coke/coal | + | |
| 23 | AQ2A | 0.83 to 0.63 | coal and wood | + | + |
| 24 | AQ2A | 0.64 to 0.56 | coal and wood | + | |
| 25 | AQ1 | 1.04 to 0.52 | coal | + | |
| | AQ2 | 0.43 to 0.10 | coal | + | |
| 26 | AQ3A | -0.06 to -0.26 | silt with coke/coal | + | + |
| 28 | AQ4 | 0.30 to 0.15 | silt with coke/coal | + | + |
| 29 | AS1 | 4.36 to 3.90 | coal and brick | + | |
| | AQ4 | 1.08 to 0.90 | coal | + | + |
| 31 | AQ4 | 0.95 to 0.65 | gravel | + | |
| 33 | AQ9B | -5.52 to -5.82 | silt with coke/coal | + | |
| 34 | AQ2 | -2.05 to -2.61 | sand with coke/coal | + | |
| 35 | AQ6 | -1.56 to -2.17 | sand with coke/coal | | |

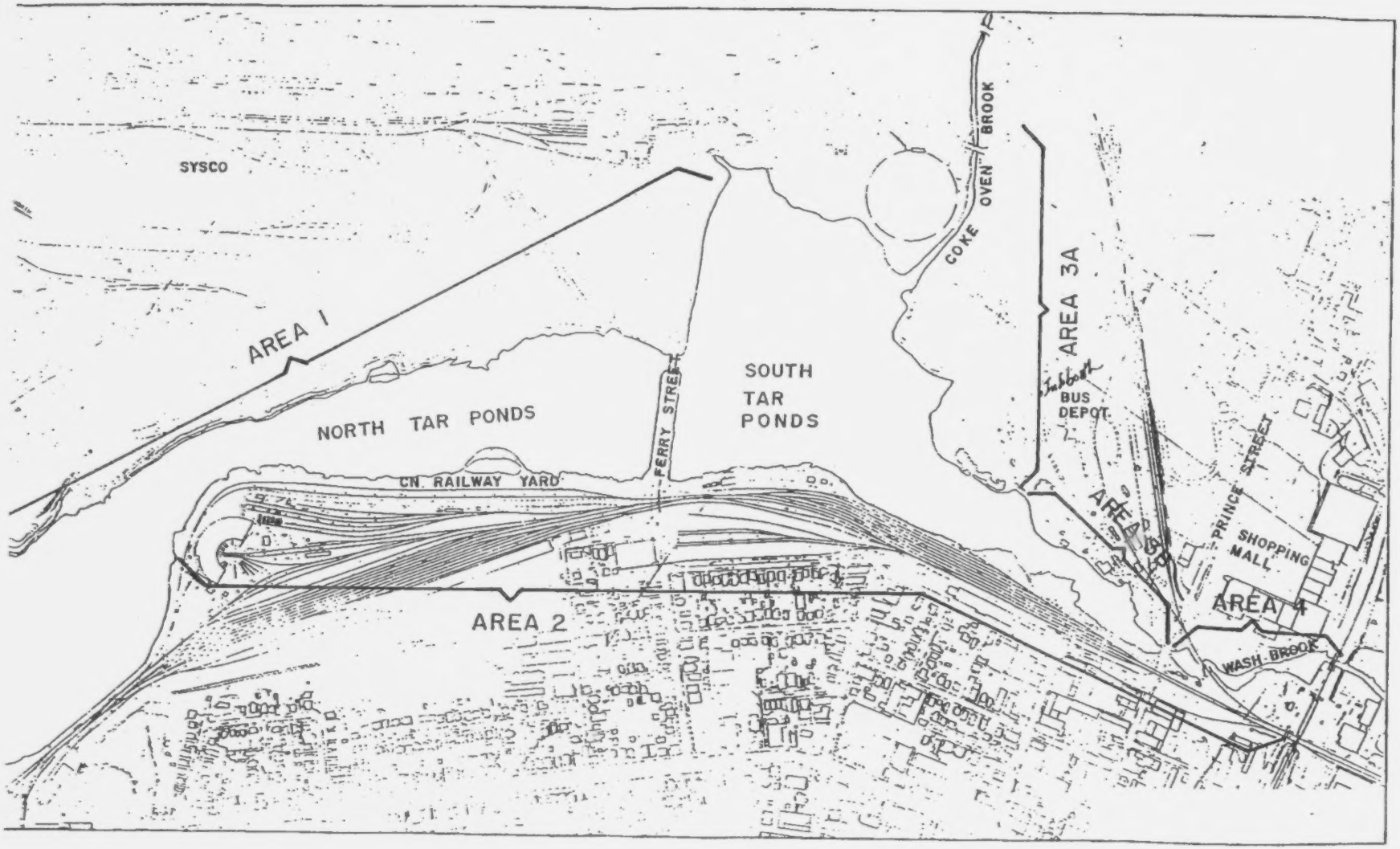


FIGURE 2

NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT
SYDNEY TAR PONDS CLEAN-UP

SHORELINE INVESTIGATION - PHASE II
SHORELINE AREAS

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# 3 Subsurface Conditions

For the purpose of the discussion in this section, the shoreline along the Tar Ponds has been subdivided into the following areas, as shown in Figure 2.

Area 1 - northeast shoreline of North Tar Pond
Area 2 - southwest shoreline of North and South Tar Ponds
Area 3 - southeast shoreline of South Tar Pond
Area 4 - shopping mall

A discussion of the subsurface conditions along the shoreline of each of these areas is provided in the following subsections. In this discussion, selected data is taken from Acres earlier reports on investigations of the shoreline and Tar Ponds. The reader is referred to these reports (Acres, 1989 and 1988 respectively) for full details on borehole conditions and soil tests results.

**Area 1 Northeast Shoreline of North Tar Pond (BH-32 to 35 and BH-101A and 102A)**

This part of the shoreline is a rugged, hilly area which was formed by the dumping of slag and other debris into Muggah Creek. This fill deposit consists of a loose to very dense heterogeneous mixture of slag, coal, brick, scrap metal and wood which rises from 3 m to in excess of 10 m above sea level (asl). It also can extend from 4 to 5 m below sea level (see Plate 2). The overall thickness of the fill varies from about 7 m at boreholes BH-34 and 102, to about 9 m and 10 m at BH-33 and BH-35, respectively, and is in excess of 15 m at BH-101.

The in-situ k test performed on the monitoring well installed in the slag materials at borehole BH-33 indicated a near-instantaneous recovery of the water level. This rapid response does not allow a determination of k using an analytical formula. However, taking into account the volume of water, the time required to introduce it into the well (18 L) and the well diameter, the k value for the slag is estimated to be in the order of at least 10 cm/s. The screen interval for this well was set in the slag from just below sea level to about 3 m above the contaminated sediments. Although the tidal level was not recorded at the time of the water level measurement in well BH-33, the very permeable nature of the slag would indicate the water level in the slag would closely follow tide level.

Table 3

PAH Distribution by Compound

| Borehole Number | Sample Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | Total PAH (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-10 | AQ1 | 0.54 | 0.00 | 2.67 | 10.00 | 65.30 | 17.00 | 69.00 | 46.30 | 34.90 | 27.00 | 43.20 | 12.70 | 26.00 | 12.00 | 16.00 | 2.40 | 391.10 |
| | AQ2 | 65.40 | 40.00 | 40.00 | 190.00 | 650.00 | 211.00 | 360.00 | 301.00 | 171.00 | 161.00 | 214.00 | 55.00 | 130.00 | 58.00 | 48.40 | 0.00 | 2794.20 |
| BH-12 | AQ1 | 28.10 | 37.20 | 14.00 | 96.00 | 213.00 | 112.00 | 160.00 | 142.00 | 106.00 | 96.30 | 113.00 | 36.10 | 65.30 | 23.40 | 30.00 | 0.00 | 1265.60 |
| BH-16 | AQ06 | 60.70 | 6.30 | 4.56 | 6.47 | 172.00 | 35.50 | 114.00 | 64.70 | 58.90 | 57.10 | 68.70 | 17.30 | 34.00 | 11.30 | 0.34 | 3.20 | 744.50 |
| BH-18 | AQ4 | 3017.00 | 480.00 | 163.00 | 1127.00 | 4832.00 | 1321.00 | 2466.00 | ****** | 1366.00 | 1067.00 | 1328.00 | 290.00 | 960.00 | 321.00 | 228.00 | 0.00 | 20804.00 |
| BH-20 | AQ4 | 6367.00 | 704.00 | 375.00 | 1628.00 | 3041.00 | 1004.00 | 1467.00 | ****** | 756.00 | 687.00 | 732.00 | 167.00 | 524.00 | 160.00 | 134.00 | 34.30 | 17254.30 |
| BH-21 | AQ2 | 3822.00 | 626.00 | 462.00 | 963.00 | 2536.00 | 772.00 | 1110.00 | 640.00 | 512.00 | 490.00 | 544.00 | 110.00 | 370.00 | 102.00 | 92.10 | 23.10 | 13910.20 |
| BH-22 | AS1 | 0.24 | 0.04 | 0.02 | 0.11 | 0.06 | 0.16 | 0.40 | 0.33 | 0.21 | 0.23 | 0.27 | 0.04 | 0.00 | 0.36 | 0.02 | 0.44 | 3.50 |
| | AQ5 | 6.04 | 6.16 | 6.61 | 0.02 | 0.04 | 2.54 | 22.30 | 10.30 | 12.00 | 12.00 | 21.20 | 4.75 | 8.07 | 4.02 | 4.42 | 0.83 | 126.24 |
| BH-23 | AQ3A | 2.42 | 0.12 | 0.21 | 0.76 | 0.61 | 1.36 | 5.70 | 5.23 | 2.44 | 2.44 | 6.16 | 1.32 | 2.36 | 1.06 | 1.16 | 0.00 | 40.01 |
| BH-24 | AS2A | 0.36 | 0.02 | 0.04 | 0.11 | 0.04 | 0.20 | 0.72 | 0.57 | 0.37 | 0.41 | 0.57 | 0.10 | 0.36 | 0.12 | 0.17 | 0.06 | 4.00 |
| BH-25 | AQ1 | 2.61 | 0.10 | 0.54 | 1.36 | 12.10 | 2.04 | 11.30 | 8.70 | 6.04 | 4.46 | 8.65 | 2.06 | 5.36 | 2.36 | 2.44 | 0.00 | 75.62 |
| | AQ2 | 0.70 | 0.00 | 0.30 | 0.30 | 2.43 | 0.71 | 3.02 | 0.10 | 1.10 | 1.00 | 1.54 | 0.47 | 0.67 | 0.44 | 0.46 | 0.00 | 12.80 |
| BH-26 | AQ3A | 11.30 | 2.30 | 0.04 | 0.76 | 46.00 | 14.00 | 36.30 | 30.00 | 17.10 | 15.50 | 21.00 | 3.00 | 10.30 | 3.74 | 3.64 | 0.00 | 237.77 |
| BH-30 | AQ4 | 127.00 | 72.20 | 16.30 | 121.00 | 310.00 | 133.00 | 234.00 | 190.00 | 118.00 | 110.00 | 136.00 | 33.30 | 61.10 | 23.66 | 24.00 | 3.22 | 1788.42 |
| BH-29 | AS1 | 0.32 | 0.04 | 0.01 | 0.04 | 0.58 | 0.10 | 0.40 | 0.24 | 0.20 | 0.23 | 0.27 | 0.07 | 0.12 | 0.03 | 0.03 | 0.00 | 2.80 |
| | AQ4 | 0.44 | 0.06 | 0.31 | 0.30 | 0.64 | 0.25 | 0.64 | 0.54 | 0.40 | 0.40 | 0.76 | 0.27 | 0.52 | 0.03 | 0.34 | 0.24 | 7.62 |
| BH-31 | AQ4 | 0.33 | 0.04 | 1.00 | 3.05 | 10.40 | 1.90 | 6.32 | 4.36 | 2.22 | 2.28 | 3.62 | 0.76 | 1.27 | 0.04 | 0.04 | 0.00 | 54.96 |
| BH-33 | AQ05 | 262.00 | 14.80 | 33.20 | 52.00 | 210.00 | 64.90 | 164.00 | 140.00 | 64.70 | 70.80 | 96.70 | 25.30 | 54.90 | 20.00 | 23.50 | 0.00 | 1506.50 |
| Duplicate | | 271.00 | 15.40 | 31.00 | 23.00 | 260.00 | 66.60 | 173.00 | 126.00 | 77.60 | 65.30 | 64.00 | 16.50 | 46.70 | 17.30 | 14.90 | 0.00 | 1332.10 |
| BH-34 | AQ2 | 123.00 | 11.90 | 17.30 | 32.70 | 111.00 | 36.00 | 57.10 | 42.40 | 24.50 | 23.00 | 27.10 | 7.17 | 17.00 | 4.62 | 4.02 | 0.00 | 538.31 |
| BH-35 | AQ6 | 2240.00 | 304.00 | 66.10 | 436.00 | 1291.00 | 542.00 | 541.00 | 432.00 | 299.00 | 279.00 | 280.00 | 82.90 | 190.00 | 60.30 | 46.70 | 12.00 | 7196.00 |
| Duplicate | | 2300.00 | 330.00 | 61.00 | 461.00 | 1660.00 | 604.00 | 454.00 | 351.00 | 243.00 | 243.00 | 220.00 | 64.50 | 140.00 | 30.30 | 27.20 | 22.00 | 6464.80 |

The fill at borehole BH-32 consists of a dense to very dense mixture of the above materials and possibly pig iron. Two unsuccessful attempts were made to auger through the fill materials in this area in adjacent boreholes. As it was not possible to auger through a layer about 4.9 m below ground surface, it was decided to attempt to drill through this zone using a core barrel. Contaminated sediments were not encountered to this point nor expected since this layer was above the level of adjacent South Tar Pond. The core barrel was advanced with difficulty to about 0.9 m into slag at which point the hole was abandoned before reaching the Tar Pond level.

The fill along the shoreline of the North Tar Pond is underlain by 1 to 2 m of very loose to compact contaminated sediment. The contaminated sediment was moist to wet and silty near the mouth of Muggah creek (BH-33) while towards the Ferry Street end of the shoreline (BH-35) it was fine to medium sand sized and dry. Contaminated sediment was not reported in BH-101 by Nolan Davis-Jacques Whitford (NDJW) in their investigation of the shoreline in late September 1989. However, in light of the fact that the contaminated sediment in the adjacent Tar Pond is about 2 m thick (see Figure 4 in Acres, 1988) and it occurs in all other boreholes along the shoreline it is possible it may have been missed in this borehole.

At boreholes BH-34 and 35 the interface between the fill and the contaminated sediments is at a level comparable to the adjacent level of the North Tar Pond. However, at boreholes BH-33, 102 and likely 101, the contaminated sediments lie about 3 to 4 m below the level of the North Tar Pond (see Plate 2). The location of these latter boreholes coincide with one of the two depositional basins in the North Tar Ponds ( see Figures 2 and 4 in Acres, 1988) while boreholes BH-34 and 35 are situated near the till ridges separating these basins and a third depositional basin in the South Tar Pond. This suggests that the level of the North Tar Pond continued to build up in the two depositional basins following the dumping of fill. Lateral displacement of the tar pond materials by dumping of fill is thought not to occur because otherwise tar pond sediments would also have been found within the lower part of the fill itself.

The chemical test results for the contaminated sediment at boreholes BH-33 to 35 all indicated similar total PAH concentrations to that in the North Tar Pond itself. This comparison is presented in Table 4.

At boreholes B-79 and B-66 the total PAH of the near-surface tar pond materials is high. However, the total PAH in the lower portion of these boreholes is comparable to that in the contaminated sediments at boreholes BH-33 and 34, respectively. At borehole B-63 (near Ferry Street), the total PAH does not vary as much in the vertical and is slightly lower than the total PAH of the contaminated sediment at borehole BH-35.

## Table 4

### Comparison of Total PAH of Contaminated Sediment Along Shoreline and North Tar Pond

| | Shoreline | | | North Tar Pond | | |
|---|---|---|---|---|---|---|
| | Borehole (BH series) | Sample Elevation (m asl) | Total PAH (mg/kg) | Borehole (B series) | Sample Elevation (m asl) | Total PAH (mg/kg) |
| Area 1 | 33 | -5.21 to -5.82 | 1,500 | 79 | -1.55 to -2.16 | 8,000 |
| | | | | | -2.16 to -2.77 | 2,900 |
| | | | | | -3.38 to -3.99 | 793 |
| | 34 | -2.05 to -2.66 | 539 | 66 | -0.21 to -0.82 | 11,700 |
| | | | | | -1.43 to -2.04 | 878 |
| | | | | | -2.04 to -2.65 | 1,450 |
| | 35 | -1.56 to -2.17 | 7,190 | 63 | 0.09 to -0.52 | 5,190 |
| | | | | | -1.74 to -2.35 | 2,490 |
| Area 2 | 10 | 0.06 to -0.55 | 2,800 | 69 | -0.61 to -1.22 | 10,100 |
| | 12 | 0.86 to 0.25 | 1,290 | 63 | 0.09 to -0.52 | 5,190 |
| | | | | | -1.74 to -2.35 | 2,490 |
| | 16 | 0.43 to -0.18 | 746 | 59 | 0.09 to -0.52 | 18,400 |

At boreholes BH-34 and 35 (and likely 101) the contaminated sediments are underlain by a light brown, very stiff, moist to dry, organic clayey silt containing shell fragments. The thickness of this deposit is similar to the thickness of the overlying contaminated sediments. At borehole BH-35, thin interbeds of contaminated sediment were found with the clayey silt. The clayey silt is not present at boreholes BH-33 or 102. This is consistent with the absence of clayey silt in the North Tar Pond near the mouth of Muggah Creek (see Fig. 3 in Acres, 1988).

A light reddish brown, compact to very dense, moist, silty till forms the basal deposit along the shoreline. The till varies from about 3 m in thickness near the mouth of Muggah creek (BH-33) to greater than 5 m towards the Ferry St. end of the shoreline (BH-35). Boreholes BH-101 and 102 indicate the till is underlain by a high to severely fractured and weathered mudstone. The k value for the upper part of this mudstone was estimated to be between 1 to $2x10^{-3}$ cm/s (NDJW, 1989).

**Area 2 - Southwest Shoreline of North and South Tar Ponds (BH-10 to 16 and 27)**

The southwest shoreline of the North and South Tar Ponds is a low-lying, flat to gently undulating area which is generally less than 3 m asl in elevation. This part of the shoreline is occupied by a Canadian National (CN) railway yard.

The uppermost deposit in the vicinity of the railway yard along the North Tar pond consists of a very loose to compact heterogeneous mixture of slag, cinders and coal with some ash, scrap wood and metal. It is between 1 and 2 m thick except at Ferry Street where these materials have been used to build up the causeway (about 4 m thick). A diesel oil odor was detected in the fill at boreholes BH-10 and 11. Along the southwest shoreline of the South Tar Pond, the uppermost deposit consists of a variety of fill materials. These include coal, cinders, peat and sand to sandy silt.

Close to the shoreline of the North Tar Pond, the fill is underlain by very loose to compact, fine sand size contaminated sediments. They are 1.7 m thick at BH-16 (Ferry Street) and less than 1 m thick elsewhere (BH-10, 11 and 12). Contaminated sediments were not found along the southwest shoreline of the South Tar Pond.

Along the southwest shoreline of the North Tar Pond, the total PAH of the contaminated sediments at boreholes BH-10, 12 and 16 is considerably lower than the total PAH of tar pond materials in adjacent boreholes (B-69, 63 and 59, respectively). However, the calorific content of the contaminated sediment at borehole BH-10 (9520 BTU/lb) is comparable to that in the North Tar Pond (see Table 4.3 from Acres, 1988).

At boreholes BH-12, 13 and 16 a light brown, very soft to soft, organic clayey silt to firm, silty sand underlies the contaminated sediments. This organic layer is about 1.5 m thick at BH-12 and 13 to slightly less than 0.6 m thick at BH-16.

The fill materials/contaminated sediments/clayey silt deposits are all underlain by a light reddish-brown, compact to very dense silty till.

The estimated pre-Tar Ponds shoreline along the North Tar Ponds bordering the CN railway yard is shown on Plate 1.

**Area 3 - Southeast Shoreline of South Tar Pond (BH-1 to 4, 8, 9, 17 to 25, 28 to 31)**

The southeast shoreline of the South Tar Pond is hilly and irregular in shape between the Bus Depot and Muggah Creek. Otherwise, the remaining area bounded by the CN railway line (near the Bus Depot), Coke Oven Brook and Muggah Creek is flat and low-lying. For the purpose of discussion in this subsection, this area is subdivided into a) the hilly to flat area bordering the South Tar Pond and Coke Oven Brook and b) the low-lying area west of the Bus Depot. Each area is separately discussed in the following subsections.

(a) Hilly to Flat Area Bordering South Tar Pond and Coke Oven Brook

The uppermost deposit over this area consists of a generally loose to compact heterogeneous mixture of coal, slag, cinders and brick. The maximum thickness of the till is about 10 m (9 to -1 m asl) near borehole BH-3 to less than 2 m in the flats adjacent to BH-9.

The total PAH of the overlying fill materials in this area ranged from less than 10 mg/kg to slightly over 100 mg/kg. Together with the fact that these materials did not display typical physical signs of contamination (tarry smells, sheens), they are considered to be uncontaminated. The calorific content of material containing coal from borehole BH-29 was less than 200 BTU/lb.

Contaminated sediments underlie the fill at the following boreholes: BH-2, 3, 8, 9, 18, 20, 21, 22, 28 and likely 31. The location of these boreholes and their relation to the pre-Tar Pond shoreline and former channel of Coke Oven Brook is shown on Plate 1. The position of the left bank of the former channel of Coke Oven Brook is estimated to lie further to the southeast than previously thought while the estimated position of the right bank is only slightly altered to the northwest.

The contaminated sediments in the flats adjacent to the South Tar Pond are largely fine to coarse gravel in size (fill materials) and are coated with finer-grained tar pond materials. Along the former right bank of Coke Oven Brook the contaminated sediments are generally fine sand to silt-sized (boreholes BH-18, 22 and 28) whereas in the central part and former right bank of the channel is typically more coarse grained (fine sand to coarse gravel in size). The contaminated sediments are about 1.5 m thick near the present shoreline of the South Tar Pond and along the former channel of Coke Oven Brook.

The in-situ k tests carried out on the monitoring wells installed in the contaminated sediments (boreholes BH-20 and 21) indicated considerably different k values. At well BH-20, the water level continues to recover some 4 months after the introduction of water into the well. This well was completed in silt to fine sand size contaminated sediment. The k value was calculated to be $2 \times 10^{-8}$ cm/s. This very low figure implies the tar-related material incorporated within the sediment largely governs the hydraulic conductivity of this material.

One comment regarding this test is that the water level initially recovered fairly quickly following the installation of the well, yet responded poorly to the introduction of water. The water level in this well corresponds to a level within the more permeable overlying fill. It is concluded that the annulus did not fully collapse around the well following its installation (i.e. bridged up). This permitted water from the overlying fill to enter the well until such time the annulus did collapse. Once this occurred, the tar-related material in the contaminated horizon (and some smearing of the borehole above this zone) limited the movement of water to the surrounding materials.

For well BH-21, completed in a mixture of gravel and fine-grained contaminated sediment, the k for this material was calculated to be $4 \times 10^{-3}$ cm/s. This value is typical of the finer-grained sediments in this material.

The contaminated sediments in this area revealed the widest range in total PAH. Taking into account previous test results in this area (see Table 2 from Acres 1989) total PAH varied from about 60 to over 20,000 mg/kg. Total PAH was low in granular materials displaying only slight physical signs of contamination at the upper reach of former Coke Oven Brook (borehole BH-31). Total PAH increased in a downstream direction from about 300 to 400 mg/kg at borehole BH-2 to about 1800 mg/kg at borehole BH-28. The highest total PAH occurred near the mouth of the former brook. Values slightly in excess of 17,000 and 20,000 were obtained from the contaminated sediment at boreholes BH-20 and 18, respectively. These values are as high as the test results for contaminated sediment in the South Tar Pond. Total PAH values near the former shoreline at the mouth were lower, decreasing to less than 3,700 mg/kg

at borehole BH-8 and 125 mg/kg at BH-22. A wide variation in total PAH was found in granular fill coated with tar pond materials near the existing shoreline. Total PAH was about 1,400 mg/kg at borehole BH-3 while values between 60 and 12,000 mg/kg were obtained from gravel materials similar in appearance at boreholes BH-9 and 21, respectively.

The calorific content of the contaminated sediment, although slightly lower than test results obtained from the South Tar Pond materials, is reasonably high. Values for the contaminated sediment ranged from slightly over 3,200 BTU/lb at borehole BH-28 to about 8,900 BTU/lb at BH-20. Calorific content increases with total PAH in the three samples tested in this area.

At boreholes BH-8 and 20 (and likely 3) the contaminated sediments are underlain by a light brown organic clayey silt. These boreholes are all situated near the former mouth and on the right channel side of former Coke Oven Brook. The thickness of this deposit is less than 2 m.

The fill/contaminated sediment/clayey silt are underlain by till. Section F-F' on Plate 2 shows the above deposit sequence near the former mouth of Coke Oven Brook and its relationship to the South Tar Pond. This section shows the fill was placed into the tar pond at a time such that the level of the pond continued to build up after infilling.

(b) Low-Lying Area West of the Bus Depot

The area west of the Bus Depot has been infilled with a variety of materials such as slag, coal, brick and scrap wood. Most of the wood materials appeared burnt. This area was evidently used as a municipal dump shortly after the turn of the century (H. Ryder - personal communication). The fill is very loose to compact and varies in thickness from about 1.5 m to 2 m (see Section H-H' on Plate 2). The lower portion of the fill at boreholes BH-4 and 25 (adjacent to the shoreline) was stained black. Tar pond materials coated the lower fill at borehole BH-4 and had a faint tarry odor. However, these materials were not present at BH-25. Contaminated sediment, per se, is not found beneath the fill. The fill instead is underlain by till.

The total PAH of the fill materials in this area is less than 80 mg/kg. Based on the test results for this area and the lack of physical signs of contamination, these materials are considered to be uncontaminated. The one exception to this is borehole BH-4 adjacent to the shoreline where gravel size fill is coated with tar pond materials.

The estimated position of the pre-Tar Pond shoreline in this area is shown on Plate 1. As can be seen from this plate the shoreline is closer to Muggah Creek than previously estimated.

**Area 4 - Shopping Mall**
**(BH-5 to 7, 26)**

The area around the mall is a low-lying, paved area varying in elevation from about 3 m near the east end of the Mall buildings to about 1.7 m near Wash Brook.

A heterogeneous mixture containing varying proportions of the following materials was encountered immediately below the asphalt pavement at all of the above-noted boreholes.

- fine gravel size slag concrete fragments
- fine to coarse gravel size brick fragment
- sand to fine gravel size coal particles

This fill deposit is compact to very dense and varies in thickness from 1.2 to 1.7 m.

At boreholes BH-5 and 26 west of the Mall buildings, the fill deposit is underlain by about 1.2 m of very loose, fine sand to silt sized contaminated sediments. This in turn is underlain by a light brown to brownish gray fine to medium sand. The sand is about 2 m thick near Wash Brook (BH-5) and thins to 0.05 m at borehole BH-26 . The sand appears to grade to the thin (<0.5 m) dark gray, firm clayey to sandy silt beneath the fill at boreholes BH-6 and 7 (see Section I-I' on Plate 2). This deposit is in turn underlain by till.

The extent of the contaminated sediments beneath the Mall buildings is not known. In the previous investigation of this area (Acres, 1989) it was thought that the contaminated sediments did not extend as far as the buildings based on the lack of this material in a trench excavated near the southwest corner of the building. However, based on the thickness of the contaminated sediments at borehole BH-26 its easterly extent from this point depends on the amount of infilling near or beneath the building prior to the introduction of contaminated material into the South Tar Pond. It should be noted that the contaminated layer extends up to 1 m asl in this area. The silt to fine sand size particles comprising this deposit could have been carried upstream and deposited at high tide levels or perhaps could have been dumped in place. However, there is little evidence to date to suggest tarry type materials have been used as fill as opposed to its association with the Tar Ponds themselves. This fact and the generally uniform grain size of these sediments, indicate its occurrence is more likely associated with tidal current redistribution of the sediments in the South Tar Pond than dumping of this material in place.

The total PAH of the fine-grained contaminated sediment at boreholes BH-26 and 5 is slightly over 200 and about 600 mg/kg, respectively. Considering the physical signs of contamination suggested these sediments were considerably contaminated, the PAH results are relatively low. The calorific content of these sediments is also low. Borehole BH-26 only indicated a value of less than 1,300 BTU/lb.

The estimated pre-Tar Pond shoreline shown along the Mall building in Plate 1 assumes the area beneath the building was largely infilled prior to the introduction of contaminated sediments into the South Tar Pond.

# 4 Clean-up Implications

The shoreline areas where the properties of the underlying contaminated sediment are similar to the adjacent tar pond materials coincide with those areas with the greatest amount of fill placed over them. This applies to the northeast shoreline of the North Tar Pond and the southeast shoreline of the South Tar Pond. Up to 16 m and 10 m of fill has been placed over these two areas, respectively. The contaminated sediment in these areas is generally suitable for incineration yet the sheer volume of overlying fill would render removal of the contaminated sediments an expensive undertaking.

A thinner layer of fill lies over less contaminated sediments along the other shoreline areas. These areas are along the North Tar Pond bordering the CN railway yard and the paved area west of the Shopping Mall. These contaminated sediments are suitable for incineration with the possible addition of a fuel supplement. However, as both of these areas are occupied parcels of land any clean-up would involve partial disruption of the existing installations and facilities.

The available options for remediating the above-noted areas are limited and in all likelihood very costly. These options are discussed in the following sections by area. The options include removal of the sediments for incineration, isolation of the sediments or a 'no corrective action' approach.

**Area 1 - Northeast Shoreline of North Tar Pond**

As the contaminated sediment underlying this area potentially extends under the entire slag dump to the Steel Mill complex, removal of this material is impractical. The thickness and nature of the fill along the shoreline also rules out most attempts to isolate the area from the Tar Ponds with some type of a barrier wall, such as sheetpiling or a bentonite slurry cutoff wall. Without deliberating the technical difficulties or merits of installing either of these walls along the shoreline, or their associated costs, it should be stated that it would be impractical to completely isolate the contaminated sediments. This would require the wall to run completely around the slag infill area in order to tie the wall off. Otherwise, potentially contaminated groundwater would simply flow around the wall, thus defeating its purpose. Hence, there are no feasible measures which could be implemented to deal with the contaminated sediments along this part of the shoreline.

'No corrective action' appears to be the only approach which can be adopted for this area. However, in defence of this approach, consider the following:

Observations during the drilling of the boreholes along this shoreline indicated that the base of the slag fill was wet, the contaminated sediment typically wet to moist at the top of the layer becoming moist to dry towards its base, the underlying organic layer (if present) dry to moist and the till moist. This suggests most of the groundwater flow in this area passes through the more permeable slag fill towards the Tar Ponds. Flow rate through the underlying materials (including the contaminated sediment) is expected to be orders of magnitude lower. This is suggested not only by their fine-grained nature but also by the above-noted moisture conditions. Based on the above, the contaminant loading to Muggah creek from the contaminated sediments is expected to be very low. It is therefore suggested that 'no corrective action' is both a reasonable and justifiable approach. Some additional information on the hydraulic and chemical properties of the contaminated sediment may be required to support this position.

**Area 3 - Southeast Shoreline of South Tar Pond**

Remediation of Area 3a faces the same difficulties as Area 1. The contaminated sediment is considered to be as contaminated as the adjacent tar pond materials, at least along the lower reaches of former Coke Oven Brook. The volume of contaminated sediment in this area is estimated to be about 70,000 $m^3$ while the volume of the overlying fill is estimated to be in excess of 400,000 $m^3$.

Although the fill in this area is not as voluminous as Area 1, it is nevertheless sufficient enough to render removal of the underlying contaminated sediment impractical unless the fill were considered to be suitable as infill for the post-clean-up tar ponds. Otherwise, the remedial options involve isolation with a barrier wall or a 'no corrective action' approach. A barrier wall could be installed around the entire perimeter of this area along the toe of the fill slope. However, unless the groundwater behind the wall were to be intercepted and treated there is little point of installing such a wall. Potentially contaminated groundwater would simply build up behind the wall until it overtopped it. It is therefore suggested that additional information on the contaminated sediments similar to that proposed for Area 1 may be required to support a 'no correction action' approach.

Area 3b is considered to be uncontaminated and therefore (with the exception of the shoreline near borehole BH-4 which should be considered as part of Area 3a) no action is required for this area.

**Areas 2 and 4 - Southwest Shoreline of North Tar Pond and Shopping Mall**

These areas both have about 1.5 m to 2 m of fill overlying the contaminated sediment. This sediment, however, is not as contaminated as the other shoreline areas. The volume of contaminated sediment underlying Area 2 is in the order of 10,000 $m^3$ while Area 4 is about 15,000 $m^3$.

Because the fill overlying the contaminated sediment in these areas is relatively thin, it is possible to clean-up these areas by removal and incineration. However, it will be very costly to remove and replace the existing installations and facilities in these areas unless the clean-up were to coincide with any proposed alterations or improvements on the part of the land owners. The tracks along the CN railway yard bordering the North Tar Pond would have to be pulled and presumably replaced while the railway line west of the Mall building and crossing Prince Street would have to be relocated. The paved areas at Prince Street and west of the Shopping Mall would also have to be torn up and repaved.

A barrier wall for Area 2 is considered impractical compared to excavation because of the elongate shape of this area in additional to other arguments previously given regarding the handling of potentially contaminated groundwater. For Area 4 a barrier wall may serve little purpose. Considering the low total PAH of the contaminated sediments in this area, the leachable fraction to groundwater is also likely to be low.

It is therefore recommended that the land owners in these two areas be contacted to ascertain future plans for their property. If replacement costs can be avoided, minimized or cost shared then it may be feasible to clean-up either or both of these areas. Otherwise a 'no corrective action' approach is suggested.

# 5 Summary and Conclusions

A follow-up investigation of the shorelines along the Tar Ponds resulted in a more accurate definition of the pre-Tar Pond shoreline along the southeast side of the upper Tar Ponds. This investigation also confirmed contaminated sediments lay under the fill materials bordering the northeast and southwest shorelines of the North Tar Pond and that they also extend from Wash Brook up to the west side of the Mall Building of the Sydney Shopping Centre.

The contaminated sediment is as contaminated as the adjacent tar pond materials along the northeast and southeast shorelines of the North and South Tar Ponds, respectively. Because of the impracticality of removing the voluminous fill overlying the contaminated sediments in these two areas or the questionable feasibility of installing a barrier wall to isolate these areas a 'no corrective action' approach is suggested. Some additional information on contaminant loadings may be required in support of this approach.

The contaminated sediment is less contaminated beneath the shoreline bordering the CN railway yard and paved area west of the Mall building. Although it would be more feasible to remove the contaminated sediments in these areas, it would be costly because of the disruption to the existing installations and facilities in these areas. Cleanup of these areas may only be feasible if the replacement costs can be avoided, minimized or cost-shared with the land owners, which in turn would depend on their future plans for their properties.

## References

Acres International Ltd., July, 1988. **Sydney Tar Ponds Clean Up, Sampling Program.** Nova Scotia Department of the Environment.

Acres International Ltd., February 1989. **Sydney Tar Ponds Clean Up, Shoreline Investigation Report.** Nova Scotia Department of the Environment.

Nolan Davis and Associates Ltd./Jacques, Whitford and Associates Ltd., September 1989. **Hydrogeologic Assessment, Sydney Tar Ponds Clean Up, Sydney, Nova Scotia.** Nova Scotia Department of the Environment.

# Appendix A
# DRILLING REPORTS

# Drilling Report

ACRES

Job P08186.00
Hole BH-10
Sheet 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 08:45, October 16, 1989
**Finished** 09:45, October 16, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 1.58 m
**Rock Surface** - 2.99 m (Assumed)
**Bottom of Hole** - 2.99 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Slag and wood | Dark reddish-brown, heterogeneous mixture of gravelly silt-size slag and wood fragments, loose, dry (fill) | AQ | 1 | 35 | 0.76 to 1.37 | 37 | 3<br>2<br>2<br>4 |
| 0.85 | Slag and ash | Dark gray heterogeneous mixture of slag and ash particles, loose, wet, diesel oil smell (fill) | | | | | | |
| 1.45 | Sand with coke/coal | Black heterogeneous mixture of fine sands and coke/coal particles, very loose, tarry smell, fluorescent sheen | AQ | 2 | 35 | 1.52 to 2.13 | 58 | 1<br>1<br>1<br>2 |
| 2.36 | Sandy silt | Light reddish-brown sandy silt, some fine gravel, trace clay, compact becoming dense with depth, wet (till) | AS | 3 | 35 | 2.29 to 2.90 | 31 | 5<br>5<br>3<br>8 |
| | | 3.51 - 3.58: gravel fragments | AS | 4 | 35 | 3.05 to 3.66 | 32 | 5<br>6<br>22<br>9 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

# Drilling Report

Job P08186.00
Hole BH-10
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| | | | AS | 5 | 35 | 3.81 to 4.42 | 61 | 11<br>15<br>18<br>45 |
| 4.57 | | End of borehole (auger refusal, bedrock assumed). | | | | | | |

# Drilling Report

Job P08186.00
Hole BH11
Sheet 1 of 2

| | | | |
|---|---|---|---|
| **Client** | Nova Scotia Department of the Environment | | |
| **Project** | Sydney Tar Ponds Clean Up | | |
| **Site** | Muggah Creek Shoreline Investigation | | |
| **Contractor** | Longyear Canada Inc. | **Started** | 10:30, October 16, 1989 |
| | | **Finished** | 11:30, October 16, 1989 |
| **Method of Drilling:** | **Soil** Hollow stem auger | **Casing Diam** | |
| | **Rock** N/A | **Core Diam** | N/A |
| **Location:** | **Latitude** See Plate 1 | **Elevations:** | **Datum** Canadian Geodetic |
| | **Departure** | | **Drilling Platform** |
| | **Bearing** N/A | | **Ground Surface** 2.44 m |
| | **Initial Dip** Vertical | | **Rock Surface** N/E |
| | **Other Dips** N/A | | **Bottom of Hole** - 0.46 m |
| | | | **Water Level** N/E |

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Rel'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Sand | Yellow, coarse sand size particles, loose, dry (fill) | AS | 1 | 35 | 0.76 to 1.37 | 34 | 2<br>2<br>3<br>2 |
| 0.90 | Coal and slag | Dark gray to reddish-brown, heterogeneous mixture of silty sand-size coal and slag particles, some gravel-size fragments, loose and dry becoming compact and wet with depth (fill) | AS | 2 | 35 | 1.52 to 2.13 | 38 | 3<br>8<br>5<br>9 |
| 1.83 | Sand with coke/coal | Black heterogeneous mixture of fine sands and coke/coal particles, compact, diesel oil smell | AQ | 3 | 35 | 2.29 to 2.90 | 48 | 4<br>1<br>6<br>3 |
| 2.39 | Sandy silt | Light reddish-brown sandy silt, some fine gravel, trace clay, compact, wet (till) | | | | | | |

**SAMPLING METHOD**

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

**SHIPPING CONTAINER**

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

ACRES

# Drilling Report

Job P08186.00
Hole BH-11
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 2.90 | | End of borehole | | | | | | |

**Notes:**

1. Sample AQ3 divided into the following two subsamples.

   AQ3A- top 10 cm of black fine sand-size coke/coal particles

   AS3B - bottom 38 cm of light reddish-brown sandy silt

# Drilling Report

Job P08186.00
Hole BH-12
Sheet 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 12:30, October 18, 1989
**Finished** 15:30, October 18, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 1.62 m
**Rock Surface** N/E
**Bottom of Hole** - 7.83 m
**Water Level** - N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal and slag | Dark gray to reddish-brown, heterogeneous mixture of coal, slag and cinders, loose, wet | AQ | 1 | 35 | 0.76 to 1.37 | 23 | 5<br>7<br>5<br>4 |
| 0.82 | Sand with coke/coal | Black gravelly fine sand-size heterogeneous mixture of coke and coal particles, compact, tarry smell | AQ | 2 | 35 | 1.52 to 2.13 | 48 | 2<br>4<br>7<br>10 |
| 1.70 | Medium sand | Light gray medium sand, some fine gravel, compact, wet | | | | | | |
| 2.15 | Clayey silt | Light brown clayey silt (organic), some shell fragments, very soft, moist | AS | 3 | 35 | 2.29 to 2.90 | 33 | 3<br>1/31cm<br>1 |
| | | | AS | 4 | 35 | 3.05 to 3.66 | 43 | 1/46cm<br>2 |

**SAMPLING METHOD**

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

**SHIPPING CONTAINER**

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved

Logged By B. Bennett
Date December 1989

# Drilling Report

Job P08186.00
Hole BH-12
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 3.38 | Sandy silt | Light brown sandy silt, some gravel, trace clay, dense, wet (till) | AS | 5 | 35 | 3.81 to 4.42 | 20 | 12<br>11<br>21<br>10 |
| | | | A | 6 | 35 | 4.57 to 5.18 | 0 | 16<br>11<br>22<br>10 |
| 5.33 | Gravelly silt | Light brown gravelly silt, some fine sand, trace clay, dense becoming very dense with depth, moist (till) | AS | 7 | 35 | 5.33 to 5.94 | 23 | 10<br>15<br>30<br>16 |
| | | | AS | 8 | 35 | 6.10 to 6.71 | 43 | 16<br>24<br>31<br>50 |
| 7.77 | Gravelly silt | Light reddish-brown to grayish-green gravelly silt, angular to subangular coarse gravel fragments, trace fine sand, dense, dry | AS | 9 | 35 | 7.62 to 7.93 | 31 | 14<br>43/16 cm |
| | | | AS | 10 | 35 | 9.14 to 9.45 | 31 | 23<br>50/16 cm |
| 9.45 | | End of borehole (sampler refusal) | | | | | | |

# Drilling Report

**Job** P08186.00
**Hole** BH-13
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 16:15, October 18, 1989
**Finished** 17:00, October 18, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 2.80 m
**Rock Surface** N/E
**Bottom of Hole** - 1.62 m
**Water Level** . N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal, slag and cinders | Dark gray to black, heterogeneous mixture of medium sand to coarse gravel-size coal, slag and cinders, very loose, dry (fill) | AS | 1 | 35 | 0.76 to 1.37 | 37 | 3<br>2<br>1<br>2 |
| | | | AZ | 2 | 35 | 1.52 to 2.13 | 8 | 1<br>1<br>3<br>3 |
| 2.21 | Sandy silt | Light reddish-brown sandy silt, some fine gravel, trace clay, very loose, wet | AS | 3 | 35 | 2.29 to 2.90 | 38 | 2<br>2<br>1/31cm |
| 2.97 | Silty sand | Light brown silty sand, (organic), some clay, firm, moist | AS | 4 | 35 | 3.05 to 3.66 | 13 | 1<br>2<br>6<br>8 |

**SAMPLING METHOD**

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

**SHIPPING CONTAINER**

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved

Logged By B. Bennett
Date December 1989

# Drilling Report

Job P08186.00
Hole BH-13
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 3.73 | Gravelly silt | Light brown gravelly silt, some fine sand, trace clay, dense, wet (till) | AS | 5 | 35 | 3.81 to 4.42 | 29 | 14<br>20<br>12<br>5 |
| 4.42 | | End of borehole | | | | | | |

# Drilling Report

Job P08186.00
Hole BH-14
Sheet 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 07:15, October 19, 1989
**Finished** 08:30, October 19, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A
**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 2.02 m
**Rock Surface** - 4.69 m (Assumed)
**Bottom of Hole** - 4.69 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal and cinders | Black heterogeneous mixture of coal and cinder particles, loose, dry | | | | | | |
| 0.81 | Sandy silt | Light brown sandy silt, some gravel, trace cinders, loose, moist (fill) | AS | 1 | 35 | 0.76 to 1.37 | 22 | 4<br>4<br>4<br>2 |
| 1.45 | Silty clay | Dark brown silty clay (organic), roots, soft, dry | | | | | | |
| 1.60 | Sandy silt | Light brownish-gray sandy silt, trace clay, inclusions of dark gray medium sand, loose, moist (fill) | AS | 2 | 35 | 1.52 to 2.13 | 45 | 2<br>3<br>4<br>8 |
| 1.80 | Sandy silt | Light reddish-brown sandy silt, some fine gravel, trace clay, compact, moist (till) | AS | 3 | 35 | 2.29 to 2.90 | 24 | 6<br>8<br>8<br>10 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved

Logged By B. Bennett
Date December 1989

# Drilling Report

AGRES

Job P08186.00
Hole BH-14
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 2.98 | Silty sand | Light brown to reddish-brown silty sand, some fine gravel, trace clay, loose, wet | AS | 4 | 35 | 3.05 to 3.66 | 28 | 4<br>3<br>3<br>2 |
| 4.10 | Gravelly silt | Light red to mauvish-brown gravelly silt, some fine sand, trace clay, dense, moist to dry (till) | AS | 5 | 35 | 4.57 to 5.18 | 37 | 5<br>14<br>23<br>25 |
| | | 6.33 - 6.43: reddish-brown coarse gravel-size mudstone fragments | AS | 6 | 35 | 6.10 to 6.71 | 33 | 7<br>6<br>13<br>18 |
| 6.71 | | End of borehole (auger refusal, bedrock assumed) | | | | | | |

# Drilling Report

Job P08186.00
Hole BH-14
Sheet 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 07:15, October 19, 1989
**Finished** 08:30, October 19, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 2.02 m
**Rock Surface** - 4.69 m (Assumed)
**Bottom of Hole** - 4.69 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal and cinders | Black heterogeneous mixture of coal and cinder particles, loose, dry | | | | | | |
| 0.81 | Sandy silt | Light brown sandy silt, some gravel, trace cinders, loose, moist (fill) | AS | 1 | 35 | 0.76 to 1.37 | 22 | 4<br>4<br>4<br>2 |
| 1.45 | Silty clay | Dark brown silty clay (organic), roots, soft, dry | | | | | | |
| 1.60 | Sandy silt | Light brownish-gray sandy silt, trace clay, inclusions of dark gray medium sand, loose, moist (till) | AS | 2 | 35 | 1.52 to 2.13 | 45 | 2<br>3<br>4<br>8 |
| 1.80 | Sandy silt | Light reddish-brown sandy silt, some fine gravel, trace clay, compact, moist (till) | AS | 3 | 35 | 2.29 to 2.90 | 24 | 6<br>8<br>8<br>10 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved

Logged By B. Bennett
Date December 1989

# Drilling Report

Job P08186.00
Hole BH-14
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 2.98 | Silty sand | Light brown to reddish-brown silty sand, some fine gravel, trace clay, loose, wet | AS | 4 | 35 | 3.05 to 3.66 | 28 | 4<br>3<br>3<br>2 |
| 4.10 | Gravelly silt | Light red to mauvish-brown gravelly silt, some fine sand, trace clay, dense, moist to dry (till) | AS | 5 | 35 | 4.57 to 5.18 | 37 | 5<br>14<br>23<br>25 |
| | | 6.33 - 6.43: reddish-brown coarse gravel-size mudstone fragments | AS | 6 | 35 | 6.10 to 6.71 | 33 | 7<br>6<br>13<br>18 |
| 6.71 | | End of borehole (auger refusal, bedrock assumed) | | | | | | |

# Drilling Report

Job P08186.00
Hole BH-15
Sheet 1 of 2

**Client** Nova Scotia Department of Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 9:00, October 19, 1989
**Finished** 9:20, October 19, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 1.58 m
**Rock Surface** N/E
**Bottom of Hole** - 0.45 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Sandy silt | Dark brown sandy silt (organic), some clay, rootlets, peat, soft, wet | AS | 1 | 35 | 0.76 to 1.37 | 51 | 1<br>2<br>3<br>8 |
| 0.97 | Sandy silt | Light brown to orangey-brown sandy silt, occasional fine gravel, trace clay, loose, moist to wet | | | | | | |
| 1.52 | Gravel | Light gray to greenish-gray coarse gravel-size sandstone fragments, dense | AS | 2 | 35 | 1.67 to 2.03 | 28 | 23<br>14<br>50/5cm |
| 2.03 | | End of borehole (sampler refusal) | | | | | | |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
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Date December 1989

AGRES

# Drilling Report

Job P08186.00
Hole BH-15
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Pene-tration Test |
|---|---|---|---|---|---|---|---|---|

**Notes:**

1. Sample AS1 divided into the following two subsamples:

   AS1A - top 20 cm of dark brown sandy silt

   AS1B - bottom 30 cm of light brown to orangey-brown sandy silt

# Drilling Report

AGRA

Job P08186.00
Hole BH-16
Sheet 1 of 3

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 10:00, October 19, 1989
**Finished** 11:40, October 19, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 4.24 m
**Rock Surface** N/E
**Bottom of Hole** - 5.18 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal, slag, cinders and brick | Heterogeneous mixture of medium sand to fine gravel-size black coal and dark brown to reddish-brown slag, cinders and brick, loose to compact, dry | AS | 1 | 35 | 1.52 to 2.13 | 34 | 4<br>1<br>3<br>3 |
| | | | AS | 2 | 35 | 3.05 to 3.66 | 41 | 19<br>15<br>15<br>7 |
| 3.66 | Slag and cinders | Dark reddish-brown becoming dark gray with depth, sandy gravel-size slag, cinders and rock fill, compact | AS | 3 | 35 | 3.81 to 4.42 | 37 | 6<br>9<br>9<br>20 |
| 3.94 | Sand with coke/coal | Black heterogeneous mixture of coarse to fine sand-size coke/coal and slag particles, some silt, very loose, wet, tarry smell | | | | | | |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
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Logged By B. Bennett
Date December 1989

Form 318 A (1)

# Drilling Report

Job P08186.00
Hole BH-16
Sheet 2 of 3

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Pene-tration Test |
|---|---|---|---|---|---|---|---|---|
| | | | A | 4 | 35 | 4.57 to 5.18 | 0 | 4<br>2<br>1<br>1 |
| | | | AQ | 5 | 35 | 5.33 to 5.94 | 43 | 0<br>1<br>2<br>1 |
| 5.64 | Clayey silt | Light brown clayey silt (organic), soft, some shell fragments | | | | | | |
| | | | AS | 6 | 35 | 6.10 to 6.71 | 33 | 3<br>10<br>16<br>12 |
| 6.20 | Sandy silt | Light brown to reddish-brown mottled sandy silt, some fine gravel, trace clay, compact to dense, moist (till) | | | | | | |
| | | | A | 7 | 35 | 7.62 to 8.23 | 0 | 6<br>18<br>20<br>11 |
| 8.68 | Sandy silt | Light reddish-brown to mauve-brown sandy silt, trace fine gravel, some clay, dense to very dense, dry (till) | | | | | | |
| | | | AS | 8 | 35 | 9.14 to 9.42 | 28 | 21<br>50/13cm |
| 9.42 | | End of borehole (sampler refusal) | | | | | | |

# Drilling Report

Job P08186.00
Hole BH-16
Sheet 3 of 3

| Depth (ft) | Soil Type | Description | Sample *Type | No. | Size (in.) | Depth (ft) | Ret'd (in.) | Pene-tration Test |
|---|---|---|---|---|---|---|---|---|

**Notes:**

1. Sample AS3 divided into the following two subsamples:

   AS3A - top 13 cm of dark reddish-brown sandy gravel size slag, cinders and rock fill

   AQ3B - bottom 24 cm of dark gray sandy gravel size coke and coal particles, tarry smell

2. Sample AQ5 divided into the following two subsamples:

   AQ5A - top 30 cm of black coarse to fine sand particles of coke and coal

   AS5B - bottom 8 cm of light brown clayey silt

# Drilling Report

Job P08186.00
Hole BH-17
Sheet 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 12:30, October 19, 1989
**Finished** 14:10, October 19, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 4.30 m
**Rock Surface** -3.37 m (Assumed)
**Bottom of Hole** -3.62 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Gravelly silt | Light brownish-red gravelly silt, some clay, trace sand, very loose to loose, moist (fill) | AS | 1 | 35 | 1.52 to 2.13 | 28 | 2<br>3<br>2<br>1 |
| 2.31 | Sand | Light brown fine sand, occasional coarse gravel, some silt, loose, wet | AS | 2 | 35 | 2.29 to 2.90 | 20 | 1<br>4<br>6<br>10 |
| 3.30 | Sandy silt | Light reddish-brown sandy silt, some fine gravel, trace clay, loose to compact, moist to dry | AS | 3 | 35 | 3.05 to 3.66 | 38 | 4<br>4<br>4<br>6 |
| | | | AS | 4 | 35 | 3.81 to 4.42 | 13 | 3<br>4<br>5<br>5 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

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Date December 1989

# Drilling Report

Job P08186.00
Hole BH-17
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| | | | AS | 5 | 35 | 4.57 to 5.18 | 31 | 3<br>6<br>50/15 cm |
| | | 4.85 to 4.87: light greenish-gray weathered gravel-size sandstone fragments | | | | | | |
| | | | A | 6 | 35 | 6.10 to 6.71 | 0 | 3<br>8<br>10<br>11 |
| | | | AS | 7 | 35 | 7.62 to 7.92 | 31 | 13<br>50/16 cm |
| 7.67 | Bedrock assumed | Fine to coarse angular gravel-size mudstone fragments, weathered, dense, moist to wet | | | | | | |
| 7.92 | | End of borehole (sampler refusal) | | | | | | |

# Drilling Report

Job P08186.00
Hole BH-18
Sheet 1 of 2

| | | | |
|---|---|---|---|
| **Client** | Nova Scotia Department of the Environment | | |
| **Project** | Sydney Tar Ponds Clean Up | | |
| **Site** | Muggah Creek Shoreline Investigation | | |
| **Contractor** | Longyear Canada Inc. | **Started** | 09:00, October 20, 1989 |
| | | **Finished** | 10:00, October 20, 1989 |
| **Method of Drilling:** | **Soil** Hollow stem auger | **Casing Diam** | |
| | **Rock** N/A | **Core Diam** | N/A |
| **Location:** | **Latitude** See Plate 1 | **Elevations:** | **Datum** Canadian Geodetic |
| | **Departure** | | **Drilling Platform** |
| | **Bearing** N/A | | **Ground Surface** 5.49 m |
| | **Initial Dip** Vertical | | **Rock Surface** N/E |
| | **Other Dips** N/A | | **Bottom of Hole** - 0.45 m |
| | | | **Water Level** - N/R |

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal and slag | Light brown to gray, heterogeneous mixture of fine to medium sand-size coal and slag particles, loose, dry becoming wet with depth | AS | 1 | 35 | 1.52 to 2.13 | 53 | 3<br>2<br>3<br>3 |
| | | 1.96 - 2.05: black medium sand-size coal particles, loose, dry, | | | | | | |
| | | | AS | 2 | 35 | 3.05 to 3.66 | 33 | 2<br>2<br>2<br>3 |
| | | | AS | 3 | 35 | 3.81 to 4.42 | 38 | 3<br>3<br>1<br>1 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
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Logged By B. Bennett
Date December 1989

AGRES

# Drilling Report

Job P08186.00
Hole BH-18
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Pene-tration Test |
|---|---|---|---|---|---|---|---|---|
| | | 4.69 - 4.75: weathered greenish gray gravel-size sandstone fragments | AQ | 4 | 35 | 4.57 to 5.18 | 31 | 3<br>19<br>20<br>3 |
| 4.75 | Sand with coke/coal | Black heterogeneous mixture of gravelly fine sand-size coke/coal particles, loose, wet, tarry smell | | | | | | |
| 5.11 | Sandy silt | Light reddish-brown sandy silt, some fine gravel, trace clay, compact, moist (till) | AS | 5 | 35 | 5.33 to 5.94 | 51 | 3<br>7<br>9<br>14 |
| 5.94 | | End of borehole | | | | | | |

# Drilling Report

**Job** P08186.00
**Hole** BH-19
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 10:45, October 20, 1989
**Finished** 12:00, October 20, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A
**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 8.32 m
**Rock Surface** N/E
**Bottom of Hole** - 0.67 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal, slag and cinders | Dark gray heterogeneous mixture of medium to fine sand-size coal, slag and cinders, some fine gravel-size coal fragments, loose, dry to wet with depth | AS | 1 | 35 | 3.05 to 3.66 | 43 | 2<br>3<br>4<br>5 |
| 6.15 | Sandy silt | Light brown sandy silt, some fine gravel, trace clay, compact becoming dense with depth, moist (till)<br><br>6.41 - 6.48: light greenish-gray gravel-size sandstone fragments | AS | 2 | 35 | 6.10 to 6.71 | 38 | 1<br>4<br>12<br>16 |
| | | | AS | 3 | 35 | 7.62 to 8.23 | 51 | 4<br>11<br>11<br>7 |

SAMPLING METHOD
*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER
N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

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Date December 1989

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ACRES

# Drilling Report

Job P08186.00
Hole BH-19
Sheet 2 of 2

| Depth (ft) | Soil Type | Description | Sample *Type | No. | Size (in.) | Depth (ft) | Ret'd (in.) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| | | | AS | 4 | 35 | 8.38 to 8.99 | 56 | 4<br>16<br>19<br>26 |
| 8.99 | | End of borehole | | | | | | |

# Drilling Report

Job P08186.00
Hole BH-22
Sheet 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 08:15, October 21, 1989
**Finished** 09:30, October 21, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 9.36 m
**Rock Surface** N/E
**Bottom of Hole** - 0.39 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Silt with coal | Heterogeneous mixture of black medium sand to silt-size coal particles and light reddish-brown sandy silt, trace clay, some yellowish-brown fine sand-size brick particles, weathered, loose, dry (fill) | AS | 1 | 35 | 3.05 to 3.66 | 28 | 2<br>3<br>4<br>4 |
| 3.96 | Clayey silt | Light reddish-brown clayey silt, some fine subangular gravel, trace sand, firm, moist (fill) | AS | 2 | 35 | 4.57 to 5.18 | 43 | 2<br>4<br>2<br>4 |
| 6.02 | Sandy silt | Dark brown sandy silt, some coarse angular to subangular gravel-size reddish mudstone and greenish-gray sandstone fragments, compact, moist (fill) | AS | 3 | 35 | 6.86 to 7.47 | 48 | 2<br>6<br>7<br>7 |

SAMPLING METHOD
*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER
N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
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Date December 1989

Form 318 A (1)

# Drilling Report

Job P08186.00
Hole BH-22
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 7.48 | Clayey silt | Light reddish-brown clayey silt, trace sand, occasional angular fine gravel-size mudstone and coarse greenish gray weathered sandstone fragments, very stiff, dry to moist (till) | AS | 4 | 35 | 7.62 to 8.23 | 36 | 3<br>9<br>8<br>7 |
| | | 8.43 - 8.56: black fine sand-size coke and coal particles, wet, fluorescent sheen | AQ | 5 | 35 | 8.38 to 8.99 | 28 | 3<br>9<br>9<br>25 |
| 8.56 | Clayey silt | Light reddish-brown clayey silt, some sand, occasional subrounded coarse gravel, very stiff, moist (till) | AS | 6 | 35 | 9.14 to 9.75 | 28 | 3<br>6<br>9<br>13 |
| 9.75 | | End of borehole | | | | | | |

# Drilling Report

Job P08186.00
Hole BH-23
Sheet 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 10:00, October 21, 1989
**Finished** 11:30, October 21, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 2.35 m
**Rock Surface** - 2.53 m (Assumed)
**Bottom of Hole** - 3.59 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Slag and brick | Dark reddish-brown heterogeneous mixture of gravelly sand-size slag and brick particles, some silt, compact, moist (fill) | AS | 1 | 35 | 0.76 to 1.37 | 48 | 7<br>6<br>4<br>7 |
| 1.38 | Coal and wood | Black fine sand-size coal particles, wood fragments and organic matter, rootlets, loose, moist, faint tarry smell | AS | 2 | 35 | 1.52 to 2.13 | 53 | 1<br>2<br>5<br>7 |
| 1.72 | Clayey silt | Light reddish-brown clayey silt, some fine sand, very stiff, moist, (till) | AS | 3 | 35 | 2.29 to 2.90 | 34 | 4<br>7<br>10<br>10 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

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Logged By B. Bennett
Date December 1989

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AGRES

# Drilling Report

Job P08186.00

Hole BH-23

Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 4.88 | Bedrock assumed | Dark brown angular gravel-size mudstone fragments | AS | 4 | 35 | 4.57 to 5.18 | 41 | 9<br>14<br>30<br>24 |
| 5.94 | | End of borehole (auger refusal) | | | | | | |

Notes:

1. Sample AS2 divided into the following two subsamples:

   AQ2A - top 20 cm of black sand-size coal particles

   AS2B - bottom 33 cm of light reddish-brown clayey silt

# Drilling Report

**Job** P08186.00
**Hole** BH-24
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 12:45, October 21, 1989
**Finished** 13:15, October 21, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 2.16 m
**Rock Surface** N/E
**Bottom of Hole** - 0.74 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal and wood | Dark brown to gray heterogeneous mixture of silty sand-size cinders, coal and wood fragments, organic, stiff, moist | AZ | 1 | 35 | 0.76 to 0.89 | 8 | 15/13cm |
| | | 0.89: boulder | | | | | | |
| 1.60 | Silty sand | Light brownish to greenish-gray silty sand, occasional rootlets | AS | 2 | 35 | 1.52 to 2.13 | 43 | 2<br>5<br>3<br>6 |
| 1.93 | Clayey silt | Light reddish-brown clayey silt, some fine gravel, trace sand, hard, moist to dry | AS | 3 | 35 | 2.29 to 2.90 | 38 | 8<br>14<br>26<br>23 |
| | | 2.46 - 2.60: light greenish-gray sandstone fragments | | | | | | |
| 2.90 | | End of borehole | | | | | | |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved

Logged By B. Bennett
Date December 1989

Form 318 A (1)

# Drilling Report

Job P08186.00
Hole BH-24
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Pene-tration Test |
|---|---|---|---|---|---|---|---|---|

**Notes:**

1. Sample AS2 divided into the following three subsamples:

   AS2A - top 8 cm of dark brown to gray heterogeneous mixture of silty sand-size cinders, coal and wood fragments

   AS2B - between 8 cm to 25 cm from top of light brownish-gray silty sand

   AS2C - bottom 18 cm of light greenish-gray silty sand

# Drilling Report

**Job** P08186.00
**Hole** BH-25
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 15:00, October 21, 1989
**Finished** 15:45, October 21, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 1.95 m
**Rock Surface** - 2.24 m (Assumed)
**Bottom of Hole** - 2.47 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal | Black to light gray fine to medium sand-size coal particles, some subangular gravel fragments, very loose to compact, moist to wet with depth | | | | | | |
| | | 0.76 - 0.91: cobbles | AQ | 1 | 35 | 0.91 to 1.52 | 52 | 3<br>2<br>8<br>7 |
| | | | AQ | 2 | 35 | 1.52 to 2.13 | 33 | 1/31cm<br>2<br>2 |
| 2.21 | Wood fragments | Black stained wood fragements | | | | | | |
| | | | AS | 3 | 35 | 2.29 to 2.90 | 10 | 2<br>1<br>4<br>3 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved J.J. Bruishaw

Logged By B. Bennett
Date December 1989

Form 318 A (1)

# Drilling Report

Job P08186.00
Hole BH-25
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 3.12 | Clayey silt | Light reddish-brown clayey silt, some fine gravel, trace sand, stiff to very stiff, moist to dry, (till) | AS | 4 | 35 | 3.05 to 3.66 | 28 | 7<br>5<br>8<br>11 |
| 4.19 | Bedrock assumed | Light reddish-brown angular fine gravel-size mudstone fragments | AS | 5 | 35 | 3.81 to 4.42 | 46 | 3<br>8<br>11<br>33 |
| 4.42 | | End of borehole | | | | | | |

**Notes:**

1. Sample AS4 divided into the following two subsamples.

   AS4A - black stained wood fragments

   AS4B - light reddish-brown clayey silt

# Drilling Report

**Job** P08186.00
**Hole** BH-26
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 07:15, October 22, 1989
**Finished** 08:15, October 22, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 2.23 m
**Rock Surface** N/E
**Bottom of Hole** - 1.42 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Brick and gravel | Dark brown to reddish-brown fine to coarse, subangular, gravel-size brick fragments, some fine sand, trace silt, very dense | AS | 1 | 35 | 0.76 to 1.01 | 18 | 13<br>50/10cm |
| 1.27 | Silt with coke/ coal | Black sandy silt-size coke and coal particles, very loose, wet, tarry smell | AQ | 2 | 35 | 1.52 to 2.13 | 13 | 1<br>1<br>1/31cm |
| 2.49 | Medium sand | Light brown medium sand | AS | 3 | 35 | 2.29 to 2.90 | 61 | 1<br>8<br>8<br>11 |
| 2.54 | Sandy silt | Light brown to light reddish-brown sandy silt, some fine gravel, trace clay, compact, moist (till) | AZ | 4 | 35 | 3.05 to 3.66 | 20 | 6<br>8<br>11<br>14 |
| 3.65 | | End of borehole | | | | | | |

SAMPLING METHOD
*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER
N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

Form 218.4 (1)

# Drilling Report

Job P08186.00
Hole BH-26
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Pene-tration Test |
|---|---|---|---|---|---|---|---|---|

**Notes:**

1. Samples AQ3 divided into two subsamples:

   AQ3A - top 20 cm of black sandy silt-size coke/coal particles

   AS3B - bottom 36 cm of light brown to reddish-brown sandy silt

# Drilling Report

**Job** P8186.00
**Hole** BH-27
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 9:15 Oct. 22, 1989
**Finished** 10:45 Oct. 22, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 3.60 m
**Rock Surface** N/E
**Bottom of Hole** - 2.34 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal | Black sandy silt-size coal particles, some rootlets, loose, dry (fill) | AS | 1 | 35 | 1.52 to 2.13 | 46 | 2<br>3<br>2<br>8 |
| 1.89 | Sand | Dark brownish-gray medium sand, some silt | | | | | | |
| 2.20 | Coal | Black fine sand to coarse angular gravel-size coal particles, some wood fragments (fill) | AS | 2 | 35 | 2.29 to 2.90 | 53 | 3<br>3<br>4<br>13 |
| 2.38 | Sandy silt | Light grayish to reddish-brown sandy silt, some fine gravel, trace clay, compact, moist to wet (till) | AS | 3 | 35 | 3.05 to 3.66 | 41 | 4<br>7<br>8<br>14 |

**SAMPLING METHOD**

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

**SHIPPING CONTAINER**

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved

Logged By B. Bennett
Date December 1989

Form 318.6 (1)

# Drilling Report

Job P8186.00
Hole BH-27
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| | | | AS | 4 | 35 | 3.81 to 4.42 | 41 | 4<br>7<br>11<br>8 |
| | | | AS | 5 | 35 | 4.57 to 5.18 | 20 | 0<br>12<br>7<br>8 |
| | | | AS | 6 | 35 | 5.33 to 5.94 | 43 | 7<br>10<br>9<br>16 |
| 5.94 | | End of borehole | | | | | | |

**Notes:**

1. Sample AS2 divided into the following two subsamples:

   AS2A - top 10 cm of black fine sand to coarse angular gravel-size coal particles

   AS2B - bottom 43 cm of light grayish to reddish brown sandy silt

# Drilling Report

**Job** P8186.00
**Hole** BH-28
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 11:15 Oct. 22, 1989
**Finished** 13:15 Oct. 22, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A
**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 5.15 m
**Rock Surface** N/E
**Bottom of Hole** - 0.79 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Slag and bricks | Black to reddish-brown fine to coarse gravel-size slag and brick fragments, some fine sand-size coal particles, loose to compact, dry becoming wet with depth (fill) | AZ | 1 | 35 | 1.52 to 2.13 | 10 | 2<br>6<br>2<br>2 |
| | | | A | 2 | 35 | 3.05 to 3.66 | 0 | 5<br>8<br>7<br>3 |
| | | | AS | 3 | 35 | 3.81 to 4.42 | 20 | 1<br>5<br>6<br>9 |
| 4.85 | Silt with coke/coal | Black sandy silt-size coke and coal particles, loose, wet, tarry smell | AQ | 4 | 35 | 4.57 to 5.18 | 43 | 7<br>6<br>3<br>4 |

SAMPLING METHOD
*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER
N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved N.V.A. Bennett

Logged By B. Bennett
Date December 1989

Form 318 A (1)

# Drilling Report

Job P8186.00
Hole BH-28
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 5.17 | Clayey silt | Light reddish brown clayey silt, some sand, occasional fine gravel, very stiff, moist (till) | AS | 5 | 35 | 5.33 to 5.94 | 25 | 8<br>12<br>8<br>13 |
| 5.94 | | End of borehole | | | | | | |

# Drilling Report

**Job** P8186.00
**Hole** BH-30
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 15:00 Oct. 22, 1989
**Finished** 15:30 Oct. 22, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 5.82 m
**Rock Surface** N/E
**Bottom of Hole** 0.64 m
**Water Level** N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal and brick | Black medium to coarse sand-size coal and brick particles, very loose, dry (fill) | AS | 1 | 35 | 1.52 to 2.13 | 51 | 1<br>1<br>1<br>1 |
| 2.54 | Coal, cinders and brick | Light gray medium sand-size coal, cinders and brick particles, some silt-size particles, loose, wet (fill) | AS | 2 | 35 | 3.05 to 3.61 | 50 | 2<br>3<br>3<br>3 |
| 3.25 | Coal, slag and brick | Light yellowish brown medium sand to coarse angular gravel-size coal, slag and brick fragments, loose wet (fill) | | | | | | |
| 4.62 | Clayey silt | Light reddish brown clayey silt, some fine sand, occasional fine gravel, stiff, moist (till) | AS | 3 | 35 | 4.57 to 5.18 | 56 | 4<br>9<br>6<br>10 |

**SAMPLING METHOD**

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

**SHIPPING CONTAINER**

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

Form 318 A (1)

# Drilling Report

Job P8186.00
Hole BH-30
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 5.18 | | End of borehole | | | | | | |

**Notes:**

1. Sample AS2 divided into the following two subsamples:

   AS2A - top 20 cm of light gray medium sand-size coal, cinders and brick particles

   AS2B - bottom 30 cm of light yellowish brown medium sand to coarse angular gravel-size coal, slag and brick fragments

# Drilling Report

**Job** P8186.00
**Hole** BH-31
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 7:30 Oct. 23, 1989
**Finished** 9:00 Oct. 23, 1989

**Method of Drilling:** **Soil** Hollow Stem Auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 5.52 m
**Rock Surface** N/E
**Bottom of Hole** - 1.03 m
**Water Level** . N/R

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Coal, slag and brick | Light whitish to reddish-brown heterogeneous mixture of fine sand to coarse gravel-size coal, slag and brick particles, very loose to compact, dry becoming wet with depth | AS | 1 | 35 | 1.52 to 2.13 | 48 | 10<br>11<br>13<br>10 |
| | | | A | 2 | 35 | 3.05 to 3.65 | 0 | 1<br>1<br>1<br>2 |
| 4.11 | Gravel | Black coal-tar coated sandy gravel, loose to compact, wet, faint tarry smell | AS | 3 | 35 | 3.81 to 4.42 | 56 | 3<br>9<br>9<br>15 |
| | | | AQ | 4 | 35 | 4.57 to 5.18 | 31 | 3<br>4<br>2<br>13 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

Form 218 & 191

# Drilling Report

Job P8186.00
Hole BH-31
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| | | | AS | 5 | 35 | 5.33 to 5.94 | 38 | 10<br>9<br>8<br>12 |
| 5.46 | Sandy silt | Light reddish to greenish brown sandy silt, some fine gravel, trace clay, compact, moist (till) | | | | | | |
| | | | AS | 6 | 35 | 6.10 to 6.55 | 46 | 3<br>11<br>15/16 cm |
| 6.55 | | End of borehole (sampler refusal) | | | | | | |

Notes:

1. Sample AS3 divided into the following two subsamples:

   AS3A - top 30 cm of light reddish brown fine sand to gravel-size slag, coal and brick particles

   AQ3B - bottom 26 cm of black coal-tar coated sandy gravel

# Drilling Report

**Job** P8186.00
**Hole** BH-32
**Sheet** 1 of 2

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 9:30 Oct. 23, 1989
**Finished** 16:00 Oct. 23, 1989

**Method of Drilling:** **Soil** Hollow Stem Auger
**Rock** NQ triple tube core barrel

**Casing Diam**
**Core Diam** 76 mm

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 5.80 m
**Rock Surface** N/E
**Bottom of Hole** 0.01 m
**Water Level** N/E

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Slag | Coarse gravel-size slag, dry<br>1.65: slag boulders | AZ | 1 | 35 | 1.52 to 1.65 | 10 | 50/13cm |
| 2.35 | Slag and brick | Dark reddish-brown sandy gravel-size slag and brick fragments, some coal particles, dense to very dense, moist | AS | 2 | 35 | 3.05 to 3.30 | 25 | 32<br>50/10cm |
| | | | AS | 3 | 35 | 3.81 to 4.42 | 43 | 24<br>36<br>15<br>29 |
| 4.57 | Slag | Coarse gravel-size slag fragments | AZ | 4 | 35 | 4.57 to 4.80 | 3 | 14<br>50/8cm |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

Form 318 A (1)

# Drilling Report

Job P8186.00
Hole BH-32
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | Sample No. | Sample Size (mm) | Sample Depth (m) | Sample Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 4.88 | Slag | Dark gray slag fragments | DS | 5 | 35 | 4.88 to 5.79 | 10 | |
| 5.79 | | End of borehole | | | | | | |

# Drilling Report

ACRES

Job P8186.00
Hole BH-33
Sheet 1 of 3

Client Nova Scotia Department of the Environment
Project Sydney Tar Ponds Clean Up
Site Muggah Creek Shoreline Investigation
Contractor Longyear Canada Inc.

Started 7:30 Oct. 24, 1989
Finished 11:00 Oct. 24, 1989

Method of Drilling: Soil Hollow stem auger
Rock N/A

Casing Diam
Core Diam N/A

Location: Latitude See Plate 1
Departure
Bearing N/A
Initial Dip Vertical
Other Dips N/A

Elevations: Datum Canadian Geodetic
Drilling Platform
Ground Surface 3.93 m
Rock Surface - 9.02 m (Assumed)
Bottom of Hole - 9.02 m
Water Level 0.44 m

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Slag | Light gray to dark brown coarse gravel-size slag fragments, some coarse sand-size particles, loose to dense, wet (fill) | AS | 1 | 35 | 1.52 to 2.13 | 15 | 7<br>5<br>8<br>13 |
| | | | AS | 2 | 35 | 3.05 to 3.66 | 31 | 11<br>22<br>10<br>21 |
| | | | AS | 3 | 35 | 3.81 to 4.42 | 28 | 5<br>7<br>4<br>3 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

Form 318 A (1)

ACRES

# Drilling Report

Job P8186.00
Hole BH-33
Sheet 2 of 3

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| | | | AS | 4 | 35 | 4.57 to 5.18 | 15 | 6<br>7<br>5<br>6 |
| | | | AS | 5 | 35 | 5.33 to 5.94 | 25 | 4<br>6<br>4<br>6 |
| | | | AS | 6 | 35 | 6.10 to 6.71 | 28 | 3<br>5<br>4<br>8 |
| | | | AS | 7 | 35 | 6.86 to 7.47 | 34 | 5<br>5<br>8<br>7 |
| | | | AS | 8 | 35 | 7.62 to 8.23 | 39 | 10<br>6<br>6<br>6 |
| 8.71 | Silt with coke/coal | Black clayey silt-size coke and coal particles, some coal-tar coated gravel, occasional rootlets, loose, wet, strong tarry smell | AQ | 9 | 35 | 9.14 to 9.75 | 61 | 2<br>2<br>2<br>3 |
| 9.44 | Silt to sand with coke/coal | Black silt to fine sand-size coke and coal particles, loose, moist to wet, tarry smell | AQ | 10 | 35 | 9.91 to 10.52 | 41 | 6<br>15<br>19<br>19 |

# Drilling Report

ACRES

Job P8186.00
Hole BH-33
Sheet 3 of 3

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 10.03 | Clayey silt | Light reddish brown clayey silt, some fine sand, occasional fine gravel, hard, moist (till) | AS | 11 | 35 | 10.67 to 11.28 | 41 | 3<br>11<br>18<br>24 |
| | | | AZ | 12 | 35 | 12.19 to 12.65 | 23 | 20<br>33<br>50/15cm |
| 12.95 | | End of borehole (auger refusal, bedrock assumed) | | | | | | |

Notes:

1. Sample AQ9 divided into the following two subsamples:

   AQ9A - top 31 cm of black clayey silt-size coke/coal particles

   AQ9B - bottom 30 cm of black silt-size coke/coal particles

2. Piezometer Installation Details

| Depth (m) | |
|---|---|
| 0.0 - 3.96 | 4.8 cm O.D. sch. 40 PVC casing (0.61 m stickup) |
| 3.96 - 5.49 | 4.8 cm O.D. sch. 40 PVC screen (20 slot) |

   Borehole allowed to collapse around well during removal of hollow stem augers.

3. Groundwater Measurements

| Date | Time | Depth (m below top casing) |
|---|---|---|
| Oct 26/89 | 07:40 | 4.10 |

# Drilling Report

Job P8186.00
Hole BH-33
Sheet 3 of 3

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 10.03 | Clayey silt | Light reddish brown clayey silt, some fine sand, occasional fine gravel, hard, moist (till) | AS | 11 | 35 | 10.67 to 11.28 | 41 | 3<br>11<br>18<br>24 |
| | | | AZ | 12 | 35 | 12.19 to 12.65 | 23 | 20<br>33<br>50/15cm |
| 12.95 | | End of borehole (auger refusal, bedrock assumed) | | | | | | |

**Notes:**

1. Sample AQ9 divided into the following two subsamples:

   AQ9A - top 31 cm of black clayey silt-size coke/coal particles

   AQ9B - bottom 30 cm of black silt-size coke/coal particles

2. Piezometer Installation Details

| Depth (m) | |
|---|---|
| 0.0 - 3.96 | 4.8 cm O.D. sch. 40 PVC casing (0.61 m stickup) |
| 3.96 - 5.49 | 4.8 cm O.D. sch. 40 PVC screen (20 slot) |

   Borehole allowed to collapse around well during removal of hollow stem augers.

3. Groundwater Measurements

| Date | Time | Depth (m below top casing) |
|---|---|---|
| Oct 26/89 | 07:40 | 4.10 |

# Drilling Report

Job P8186.00
Hole BH-34
Sheet 1 of 2

| | | | | |
|---|---|---|---|---|
| Client | Nova Scotia Department of the Environment | | | |
| Project | Sydney Tar Ponds Clean Up | | | |
| Site | Muggah Creek Shoreline Investigation | | | |
| Contractor | Longyear Canada Inc. | Started | 12:45 | Oct. 24, 1989 |
| | | Finished | 16:00 | Oct. 24, 1989 |
| Method of Drilling: | Soil Hollow stem auger | Casing Diam | | |
| | Rock N/A | Core Diam | N/A | |
| Location: | Latitude See Plate 1 | Elevations: | Datum | Canadian Geodetic |
| | Departure | | Drilling Platform | |
| | Bearing N/A | | Ground Surface | 6.33 m |
| | Initial Dip Vertical | | Rock Surface | N/E |
| | Other Dips N/A | | Bottom of Hole | - 9.04 m |
| | | | Water Level . | N/E |

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Slag | Light gray gravel size slag fragments, loose to dense | | | | | | |
| 7.0 | Sand with coke/coal | Black medium sand-size coke and coal particles, very loose to compact, wet becoming moist with depth, tarry smell | AQ | 1 | 35 | 7.62 to 8.23 | 41 | 1<br>7<br>12<br>12 |
| | | 7.62 - 7.67: coal-tar coated gravel fragments | | | | | | |
| | | | AQ | 2 | 35 | 8.38 to 8.99 | 61 | 1<br>2<br>1<br>9 |
| 8.94 | Silty sand | Light brown silty sand (organic), some shell fragments, very soft becoming stiff with depth, moist | | | | | | |
| | | | AS | 3 | 35 | 9.14 to 9.75 | 61 | 0<br>4<br>6<br>8 |

SAMPLING METHOD

*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER

N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

Form 318-A (1)

# Drilling Report

Job P8186.00
Hole BH-34
Sheet 2 of 2

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 9.83 | Clayey silt | Light brown clayey silt (organic), some rootlets, very stiff, moist to dry | AS | 4 | 35 | 9.91 to 10.52 | 46 | 2<br>8<br>13<br>19 |
| 10.29 | Sandy silt to gravelly sand | Light reddish brown sandy silt becoming gravelly sand with depth, some clay to trace clay with depth, occasional fine gravel, compact, moist (till) | AZ | 5 | 35 | 10.67 to 11.28 | 36 | 9<br>15<br>15<br>17 |
| | | | AS | 6 | 35 | 12.19 to 12.80 | 36 | 7<br>11<br>13<br>15 |
| | | | AZ | 7 | 35 | 15.24 to 15.37 | 10 | 50/13 cm |
| 15.37 | | End of borehole (sampler refusal) | | | | | | |

# Drilling Report

Job P8186.00
Hole BH-35
Sheet 1 of 3

**Client** Nova Scotia Department of the Environment
**Project** Sydney Tar Ponds Clean Up
**Site** Muggah Creek Shoreline Investigation
**Contractor** Longyear Canada Inc.

**Started** 8:15 Oct. 25, 1989
**Finished** 16:00 Oct. 25, 1989

**Method of Drilling:** **Soil** Hollow stem auger
**Rock** N/A

**Casing Diam**
**Core Diam** N/A

**Location:** **Latitude** See Plate 1
**Departure**
**Bearing** N/A
**Initial Dip** Vertical
**Other Dips** N/A

**Elevations:** **Datum** Canadian Geodetic
**Drilling Platform**
**Ground Surface** 9.11 m
**Rock Surface** N/E
**Bottom of Hole** - 5.22 m
**Water Level** N/E

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| 0.0 | Slag | Light gray sandy gravel-size slag fragments, compact to very dense, moist to wet | AS | 1 | 35 | 6.86 to 7.47 | 28 | 13<br>14<br>10<br>10 |
| | | | A | 2 | 35 | 7.62 to 8.23 | 0 | 45<br>17<br>26<br>16 |
| | | | A | 3 | 35 | 8.38 to 8.99 | 0 | 14<br>13<br>5<br>2 |

SAMPLING METHOD
*A – split tube
B – thin wall tube
C – piston sampler
D – core barrel
E – auger
F – wash

SHIPPING CONTAINER
N – insert
O – tube
P – water content tin
Q – glass jar
R – cloth bag
S – plastic bag
Y – core box
Z – discarded

Inspector B. Bennett
Approved
Logged By B. Bennett
Date December 1989

# Drilling Report

Job P8186.00
Hole BH-35
Sheet 2 of 3

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Penetration Test |
|---|---|---|---|---|---|---|---|---|
| | | | AS | 4 | 35 | 9.14 to 9.75 | 10 | 50/10 cm |
| | | | AZ | 5 | 35 | 9.91 to 10.52 | 8 | 18<br>8<br>4<br>8 |
| 10.33 | Sand with coke/coal | Black silty fine sand-size coke and coal particles, loose, dry, tarry smell | AQ | 6 | 35 | 10.67 to 11.28 | 61 | 2<br>3<br>5<br>7 |
| | | | AQ | 7 | 35 | 11.43 to 12.04 | 53 | 1<br>5<br>8<br>12 |
| 11.84 | Clayey silt | Light brown clayey silt (organic), some shell fragments, very stiff, dry | | | | | | |
| | | | AQ | 8 | 35 | 12.19 to 12.80 | 48 | 5<br>10<br>14<br>18 |
| | | 12.24 - 12.37: Interbeds of black<br>12.53 - 12.56: silty fine sand-size coke/coal particles, dry | | | | | | |
| | | | AS | 9 | 35 | 12.95 to 13.56 | 61 | 6<br>10<br>12<br>13 |
| 13.39 | Silty sand | Light reddish-brown silty sand, some coarse gravel, trace clay, compact to very dense, moist (till) | | | | | | |
| | | | AS | 10 | 35 | 13.72 to 14.33 | 46 | 8<br>18<br>37<br>10 |
| 14.33 | | End of borehole | | | | | | |

AGRA

# Drilling Report

Job P8186.00

Hole BH-35

Sheet 3 of 3

| Depth (m) | Soil Type | Description | Sample *Type | No. | Size (mm) | Depth (m) | Ret'd (cm) | Pene-tration Test |
|---|---|---|---|---|---|---|---|---|

**Notes:**

1. Sample AQ7 and AQ8 divided into the following two subsamples:

   AQ7A - top 40 cm of black silty fine sand size coke and coal particles

   AS7B - bottom 13 cm of light brown clayey silt (organic)

   AQ8A - 5 cm to 18 cm from top of black silty fine sand-size coke and coal particles

   AS8B - 18 cm to 34 cm from top of light brown clayey silt (organic)

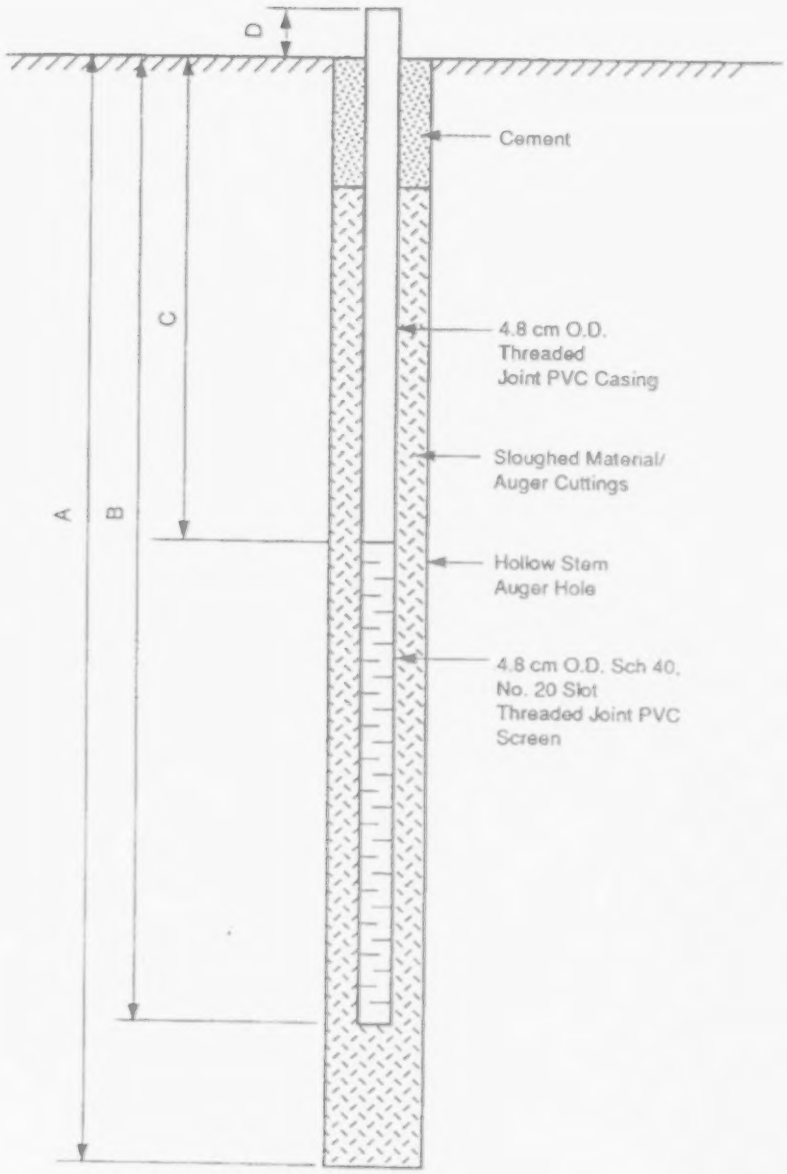


Fig. 1

Nova Scotia Department of the Environment
Sydney Tar Ponds Clean-Up
Muggah Creek Shoreline Investigation

ACRES

# Appendix B
# CALORIFIC AND CHEMICAL ANALYSES

**rpc**

research and productivity council
conseil de recherche et de productivité

*FAX*

PAGE 1 OF 6

FAX Ref. #902-429-9358

Our Fax Number Is (506) 452-1395.

TO : Mr. H. MacDonald DATE: Dec 5 TIME: 11:00 a.m.

COMPANY: Acres International Ltd.

FROM : See Hua Tan

SUBJECT:

**********

SIGNED

NOVA SCOTIA RESEARCH FOUNDATION CORPORATION
P.O.BOX 100 Fenwick Street
Dartmouth, Nova Scotia, B2Y 3Z7

ACRES INTERNATIONAL LTD.
SYDNEY TAR POND SAMPLES

Samples Rec'd: Nov. 15/89
Reported: Nov.30/89

| Lab No. | Acres Sample No | % Air Dried Moisture | % Moisture (ASTM D3173) | % Ash | % Total Sulpher | % C | % H | % N | % Volatiles | BTU/lb | % Oxygen (By Diff.) | % Fixed Carbon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W682/1 | TPH1492 | 45.0 | 2.14 | 35.20 | 3.57 | 55.04 | 3.34 | 0.97 | 30.3 | 9523 | 1.88 | 32.36 |
| /2 | TPH1497 | 22.3 | 1.63 | 37.10 | 2.62 | 56.16 | 3.34 | 0.90 | 27.3 | 8905. | 0.00 | 33.92 |
| /3 | TPH1499 | 29.0 | 2.41 | 42.23 | 1.75 | 50.91 | 2.83 | 0.79 | 24.4 | 7248 | 1.49 | 31.26 |
| /4 | TPH1503 | 44.5 | 1.51 | 80.60 | 1.63 | 14.25 | 1.26 | 0.29 | 23.9* | 1940 | 1.97 | — |
| /5 | TPH1508 | 28.3 | 0.93 | 86.65 | 0.90 | 11.15 | 0.86 | 0.13 | 7.77 | 1259 | 0.31 | 4.65 |
| /6 | TPH1510 | 29.8 | 1.22 | 75.90 | 0.96 | 21.82 | 1.42 | 0.22 | 14.7 | 3253 | 0.00 | 8.10 |
| /7 | TPH1513 | 31.7 | 1.22 | 88.30 | 0.93 | 7.44 | 0.67 | 0.08 | 7.47 | <200 | 2.08 | 3.01 |
| NSRFC CONTROL | | | 2.35 | 43.66 | 1.63 | 48.14 | 3.14 | 0.82 | 21.56 | 80[illegible] | | |

QUALITY CONTROL (Daily Run with NBS Certified Values in Brackets)

| % Moisture | % Volatile Matter | % Total Sulphur | BTU/lb | % Carbon | % Hydrogen | % Nitrogen |
|---|---|---|---|---|---|---|
| 1.00 | 36.[illegible]35.4± 1.10 | 1.84(1.89±0.06) | 13895 (14005±35) | 78.12(78.11±0.037) | 5.10(5.07±0.06) | 1.45(1.56±0.07) |

Value was rechecked and accuracy confirmed. This sample does not seem to respond to volatile analysis as described for coal.

* CHN Analyzer

J.W. Thorpe, Ph.D., M.B.A.
Director of Laboratory Services

**Analysis of PAHs in soil samples (ppm, as received)**

| | TPM1490 | TPM1491 | TPM1493 | TPM1494 | TPM1495 |
|---|---|---|---|---|---|
| Naphthalene | 9.54 | 85.4 | 28.1 | 80.7 | 3017 |
| Acenaphthylene | 0.00 | 48.9 | 37.2 | 6.20 | 489 |
| Acenaphthene | 2.67 | 66.5 | 14.9 | 4.58 | 183 |
| Fluorene | 10.0 | 190 | 96.9 | 6.47 | 1127 |
| Phenanthrene | 65.2 | 658 | 213 | 173 | 4332 |
| Anthracene | 17.9 | 211 | 112 | 35.5 | 1321 |
| Fluoranthene | 60.6 | 398 | 169 | 114 | 2488 |
| Pyrene | 48.3 | 301 | 142 | 84.7 | 2024 |
| Bz(a)anthracene | 34.9 | 171 | 106 | 58.9 | 1366 |
| Chrysene | 27.9 | 161 | 96.2 | 57.1 | 1087 |
| Bz(b)fluoranthene | 43.2 | 216 | 113 | 59.7 | 1328 |
| Bz(e)pyrene | 12.7 | 55.0 | 36.1 | 17.3 | 298 |
| Bz(a)pyrene | 26.9 | 130 | 65.3 | 24.6 | 995 |
| Indenopyrene | 12.9 | 56.0 | 23.4 | 11.3 | 321 |
| Bz(ghi)perylene | 15.9 | 48.4 | 30.6 | 9.34 | 228 |
| Dibz(ah)anthracene | 2.49 | 0.00 | 6.90 | 3.20 | 0.00 |
| Dry Weight (%) | 70.2 | 51.9 | 83.7 | 68.5 | |

Note: TPM1495 contained mostly rocks, dry weight was not determined.

| | TPM1496 | TPM1498 | TPM1500 | TPM1501 | TPM1502 |
|---|---|---|---|---|---|
| Naphthalene | 5287 | 2602 | 0.24 | 0.04 | 2.42 |
| Acenaphthylene | 706 | 505 | 0.04 | 0.18 | 0.12 |
| Acenaphthene | 375 | 402 | 0.02 | 0.51 | 0.21 |
| Fluorene | 1028 | 983 | 0.11 | 0.92 | 0.70 |
| Phenanthrene | 3041 | 2535 | 0.66 | 9.06 | 6.51 |
| Anthracene | 1004 | 772 | 0.15 | 2.54 | 1.20 |
| Fluoranthene | 1467 | 1119 | 0.40 | 22.2 | 5.79 |
| Pyrene | 1160 | 840 | 0.33 | 19.3 | 5.22 |
| Bz(a)anthracene | 758 | 512 | 0.21 | 12.9 | 3.44 |
| Chrysene | 697 | 490 | 0.23 | 12.6 | 3.44 |
| Bz(b)fluoranthene | 733 | 546 | 0.27 | 21.2 | 5.11 |
| Bz(e)pyrene | 167 | 119 | 0.04 | 4.75 | 1.32 |
| Bz(a)pyrene | 524 | 370 | 0.08 | 8.97 | 2.30 |
| Indenopyrene | 160 | 102 | 0.35 | 4.82 | 1.08 |
| Bz(ghi)perylene | 124 | 92.1 | 0.02 | 4.42 | 1.15 |
| Dibz(ah)anthracene | 24.3 | 21.1 | 0.44 | 0.83 | 0.00 |
| Dry Weight (%) | 76.4 | 66.5 | 83.8 | 60.3 | 45.2 |

| | TPM1504 | TPM1505 | TPM1506 | TPM1507 | TPM1509 |
|---|---|---|---|---|---|
| Naphthalene | 0.39 | 2.81 | 0.79 | 11.3 | 127 |
| Acenaphthylene | 0.03 | 0.19 | 0.00 | 2.59 | 72.2 |
| Acenaphthene | 0.04 | 0.54 | 0.39 | 6.64 | 15.2 |
| Fluorene | 0.11 | 1.36 | 0.39 | 9.76 | 121 |
| Phenanthrene | 0.64 | 12.1 | 2.43 | 49.0 | 319 |
| Anthracene | 0.20 | 2.14 | 0.71 | 14.8 | 133 |
| Fluoranthene | 0.72 | 11.3 | 2.02 | 36.2 | 234 |
| Pyrene | 0.57 | 9.76 | 0.18 | 30.6 | 199 |
| Bz(a)anthracene | 0.37 | 6.64 | 1.10 | 17.1 | 119 |
| Chrysene | 0.41 | 6.48 | 1.09 | 15.5 | 118 |
| Bz(b)fluoranthene | 0.57 | 9.65 | 1.56 | 21.9 | 136 |
| Bz(e)pyrene | 0.18 | 2.69 | 0.47 | 3.80 | 33.3 |
| Bz(a)pyrene | 0.30 | 5.36 | 0.87 | 10.2 | 81.1 |
| Indenopyrene | 0.13 | 2.36 | 0.44 | 3.74 | 23.5 |
| Bz(ghi)perylene | 0.17 | 2.44 | 0.46 | 3.84 | 34.8 |
| Dibz(ah)anthracene | 0.05 | 0.00 | 0.00 | 0.80 | 3.52 |
| Dry Weight (%) | 61.0 | 74.7 | 57.1 | 67.6 | 58.9 |

| | TPM1511 | TPM1512 | TPM1514 | TPM1515 | TPM1515D |
|---|---|---|---|---|---|
| Naphthalene | 0.32 | 0.44 | 6.33 | 282 | 271 |
| Acenaphthylene | 0.04 | 0.06 | 0.64 | 16.8 | 15.4 |
| Acenaphthene | 0.01 | 0.31 | 1.09 | 33.2 | 31.8 |
| Fluorene | 0.08 | 0.28 | 3.85 | 52.8 | 33.9 |
| Phenanthrene | 0.59 | 0.84 | 19.4 | 316 | 260 |
| Anthracene | 0.16 | 0.25 | 1.99 | 84.9 | 90.8 |
| Fluoranthene | 0.40 | 0.64 | 6.32 | 194 | 173 |
| Pyrene | 0.34 | 0.54 | 4.38 | 148 | 126 |
| Bz(a)anthracene | 0.20 | 0.40 | 2.22 | 84.7 | 77.6 |
| Chrysene | 0.23 | 0.40 | 2.28 | 70.8 | 65.3 |
| Bz(b)fluoranthene | 0.27 | 0.76 | 3.02 | 98.7 | 86.6 |
| Bz(e)pyrene | 0.07 | 0.27 | 0.78 | 25.3 | 19.5 |
| Bz(a)pyrene | 0.12 | 0.52 | 1.37 | 56.9 | 48.7 |
| Indenopyrene | 0.03 | 0.53 | 0.64 | 20.9 | 17.7 |
| Bz(ghi)perylene | 0.03 | 0.54 | 0.64 | 23.5 | 14.8 |
| Dibz(ah)anthracene | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 |
| Dry Weight (%) | 81.2 | 68.5 | 65.5 | 52.6 | 52.6 |

| | TPM1516 | TPM1517 | TPM1517D |
|---|---|---|---|
| Naphthalene | 123 | 2269 | 2300 |
| Acenaphthylene | 11.9 | 356 | 330 |
| Acenaphthene | 17.3 | 66.1 | 41.9 |
| Fluorene | 32.7 | 430 | 401 |
| Phenanthrene | 111 | 1291 | 1000 |
| Anthracene | 36.0 | 542 | 604 |
| Fluoranthene | 57.1 | 541 | 458 |
| Pyrene | 42.4 | 432 | 351 |
| Bz(a)anthracene | 24.5 | 299 | 243 |
| Chrysene | 23.0 | 279 | 243 |
| Bz(b)fluoranthene | 27.1 | 290 | 220 |
| Bz(e)pyrene | 7.17 | 82.9 | 64.5 |
| Bz(a)pyrene | 17.0 | 190 | 140 |
| Indenopyrene | 4.52 | 60.2 | 39.3 |
| Bz(ghi)perylene | 4.62 | 46.7 | 27.2 |
| Dibz(ah)anthracene | 0.00 | 12.0 | 22.0 |
| Dry Weight (%) | 63.4 | 61.1 | 61.1 |

Note: TPM1515D and TPM1517D were duplicate analyses of TPM1515 and TPM1517 respectively.

# Appendix C
# PLATES